AGRICULTURAL ENGINEERING

DECEMBER • 1953

In this Issue . . .

THE JOURNAL OF THE
AMERICAN SOCIETY OF AGRICULTURAL ENGINEERS

16mm—FULL COLOR and SOUND

PRIZE-WINNING MOVIE SHOWS HOW TO MAKE ONE PASTURE ACRE EQUAL FOUR

One pasture acre—renovated, fertilized, and sown to improved forage varieties—can produce as much meat and milk as four acres did before. This prize-winning Case educational motion picture and companion take-home booklet show how to do it with ordinary farm equipment.

FILM AND TAKE-HOME BOOKLETS AVAILABLE WITHOUT CHARGE

CASE

60 TEACHING AIDS As a contribution to a more prosperous and enduring agriculture, the J. I. Case Company has prepared more than sixty educational, non-advertising movies, slide films, booklets, posters, study outlines, etc. Freely available to farm and civic clubs, instructors, county agents, etc., films are loaned and printed matter furnished without charge. Ask your Case dealer or branch for the latest visual aids catalog which describes each and tells how to order. Always order enough booklets so that each member of the audience may take one home. J. I. Case Co., Racine, Wis.

BIG

FOR MINE HAULING
Photo Courtesy Hendrickson Motor Truck Co.

Jobs Can't Afford to Be Kept Idle by Needless Down-Time

FOR TRANSPORT WORK
Photo Courtesy Dart Truck Co.

FOR TRACTOR TOWING
Photo Courtesy M-R-S Co.

FOR OFF-HIGHWAY JOBS
Photo Courtesy Hendrickson Motor Truck Co.

Why Not Give YOUR Truck MECHANICS Advantages?

MECHANICS Roller Bearing UNIVERSAL JOINTS will give your trucks *more road time and less shop time* because MECHANICS JOINTS are specially designed with less parts and connections — *for easy assembly and servicing — smooth running balance — maximum strength with less weight — and long, trouble-free, safe operation.* Either the joints or brake drum can be serviced independently without disturbing other attachments or altering original drum or propeller shaft balance. Let MECHANICS engineers give *your* trucks or other heavy-duty machines these competitive advantages.

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UNIVERSAL JOINT
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2046 Harrison Ave.
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Roller Bearing
UNIVERSAL JOINTS

For Cars • Trucks • Tractors • Farm Implements • Road Machinery • Aircraft • Tanks • Busses and Industrial Equipment

AGRICULTURAL ENGINEERING

Established 1920

CONTENTS • DECEMBER, 1953 • VOL. 34, NO. 12

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INDEX TO VOLUME 34

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LINK-BELT integrates all components to give you the right screw conveyor for your machines

Whether your screw conveying problem is conveying, elevating, feeding, mixing, blending or spreading, you'll find the right answer at Link-Belt.

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Your Link-Belt representative can give you full information on the extensive line of Link-Belt Screw Conveyor components. Compare this complete choice of quality products with any other . . . and you'll choose Link-Belt every time.

LINK-BELT

SCREW CONVEYORS

LINK-BELT COMPANY: Plants: Chicago, Indianapolis, Philadelphia, Colmar, Pa., Atlanta, Houston, Minneapolis, San Francisco, Los Angeles, Seattle; Scarboro, Toronto and Elmira, Ont. (Canada); Springs (South Africa); Sydney (Australia). Sales Offices in Principal Cities. 13,163-A

Recognized for high quality preparation at big capacity, Letz Model 220 X feed mills granulate, crack or pulverize a wide variety of feeds. Positive Link-Belt Screw Conveyors are employed to elevate the full grinder output with minimum power consumption. Positive PTO drive through Link-Belt Roller Chain increases grinder capacity, makes possible "ONE-MAN" operation.

LINK-BELT builds augers and screw conveyors for farm machinery of all types

Combines

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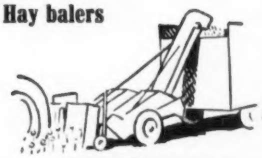
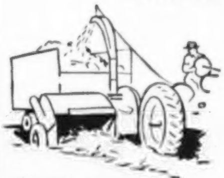
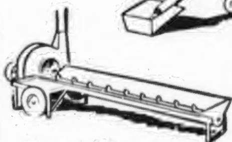


Cotton harvesters

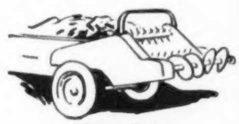


Forage harvesters

Grain loaders

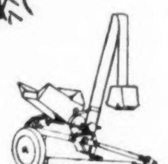


Forage blowers



Spreaders

Post hole diggers

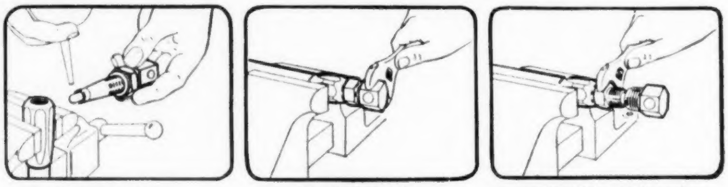


Feed grinders

Make Your Own Hose Lines

AEROQUIP HOSE AND FITTINGS ARE MATCHED FOR GUARANTEED PERFORMANCE

• No skill or special training is required to assemble Aeroquip Flexible Hose Lines by hand *in a matter of minutes!* YOU CUT COSTS because Aeroquip fittings are detachable and may be used again and again. YOU REDUCE INVENTORY because with Aeroquip bulk hose and a few fittings you can fill practically all your hose line requirements. YOU REDUCE DOWNTIME because with Aeroquip on hand, quick hose line replacements are available at all times.



Cut hose to length with hacksaw; screw into socket.

Oil nipple and inside of hose liberally.

Screw nipple into socket and hose.

Install fitting on other end; hose line is ready for use.

Aeroquip

REG. TRADE MARK

AEROQUIP CORPORATION, JACKSON, MICHIGAN

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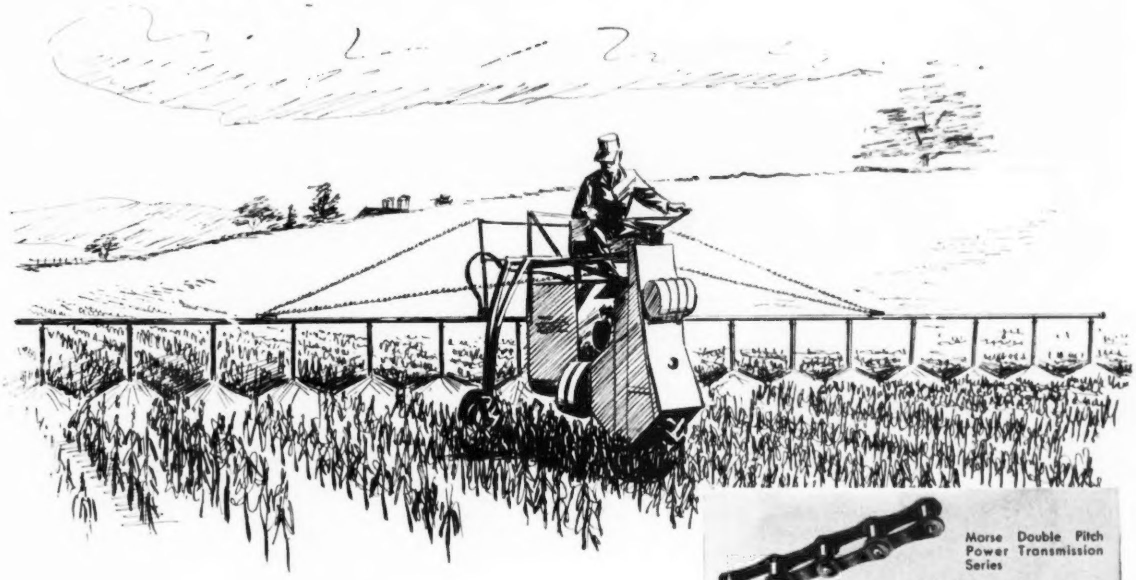
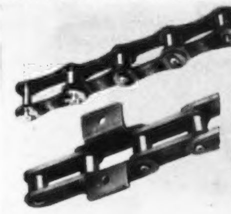




Morse Double Pitch Power Transmission Series

Morse Double Pitch Standard Chain—with attachments. Available with bent or straight attachment plates, one or two attachment holes, standard or large rollers. Pitch sizes from 1" to 2½".

Quick refresher facts

ON MORSE DOUBLE PITCH CHAINS

You gain parts economy and ncreased customer satisfaction when you equip your farm machinery with Morse Double Pitch Chains

DESIGN, ECONOMY FACTORS

You cut problems raised by gradual pitch elongation to a new low with these tough, precision-built, steel chains. Your customers will welcome freedom from maintenance cost, time loss and annoyance.

Morse Double Pitch Chains come in two series, *Power Transmission* and *Conveyor*. Both series are adaptable to a maximum range of applications, can be used with standard and special attachments

Double Pitch Chains are ideally suited for applications where rotative speeds are low and the power to be transmitted is within the capacity of a single strand chain. In comparison with standard roller chains, they weigh less, cost less; with proper care, they provide the same long life. Parallel strands wear evenly—a particular advantage for conveying work.

STAMINA FACTORS

Morse Double Pitch Chains will wear longer, give more satisfactory all-round performance, help reduce downtime. Here are a few reasons:

1. PINS. Heat-treated special high-nickel, fine grain alloy steel pins have extremely hard case for wear resistance, tough inner core for high strength.

2. PIN LINKS. In Morse Double Pitch Chains, heavy press fit holds pins immobile in pin link plates. Accuracy of assembly and close fit tolerance of pin and plate components assure proper clearances between pins and bushings.

3. BUSHINGS. Morse bushings are case hardened and heat treated for maximum wear. Smooth inner bearing surfaces and true roundness help eliminate pin scoring, increase joint life, reduce elongation.

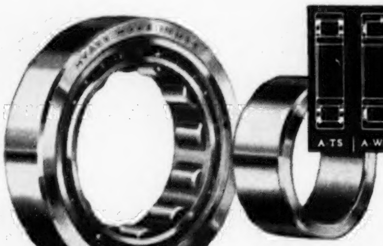
4. ROLLERS. Rollers, processed from special alloy steel, are shot-peened for maximum wear and resistance to shock.

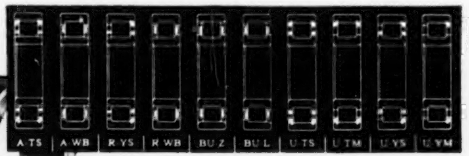
5. LINK PLATES. Morse link plates are specially treated to obtain maximum structural strength and maximum endurance qualities necessary in highly stressed tension parts.

If you'd like sound, effective engineering help on drive design, attachment selection, or any related mechanical-power-transmission problem that's bothering you, let us put you in touch with one of our skilled Morse Men. Or, write for Catalog C52-52. MORSE CHAIN COMPANY, Dept. 561, 7601 Central Ave., Detroit 10, Michigan.

M-PT
MORSE *means* **POWER TRANSMISSION**

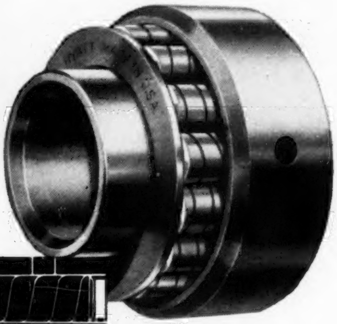
MORSE
BW
MECHANICAL POWER TRANSMISSION PRODUCTS





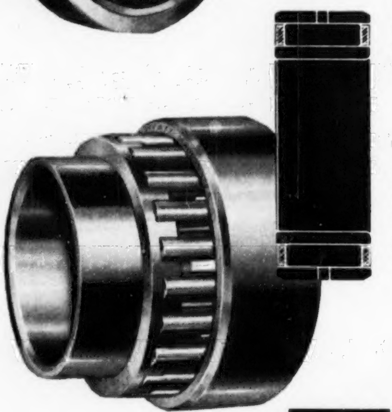
HY-LOAD

High-capacity, cylindrical roller bearings for heaviest radial loads and light or intermittent thrust loads. Produced in 3 diameter series, 2 widths and more than 800 sizes.



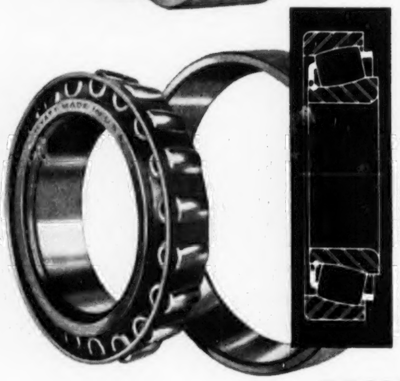
WOUND ROLLER

This is a three-part separable bearing available in various width classifications. The roller construction provides maximum resistance to shock, abrasion and fatigue.



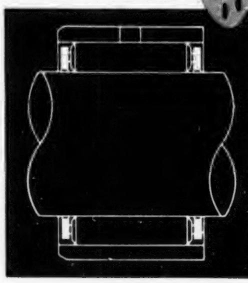
INDUSTRIAL INCH

Designed for slow-moving, heavily loaded machinery where large-diameter shafts are the rule. Accordingly, it is available in fractional-size bores for shafts from 4″ in diameter upwards.



BARREL

A series of angular-contact, self-aligning bearings capable of sustaining both radial and thrust loads. Race and roller curvatures insure ideal distribution of load, not only for normal operation but also for conditions of misalignment.



TRUNNIONED ROLLER

Ideal for industrial trucks, textile machinery, gear pumps, conveyors, hoists and agricultural equipment. Rollers have trunnioned ends which fit into holes in the end rings. End rings are located and held parallel by spacing bars which also guide and retain rollers.

DESIGNED FOR HEAVY DUTY...

HYATT ROLLER BEARINGS

...and there's a type and size for every need

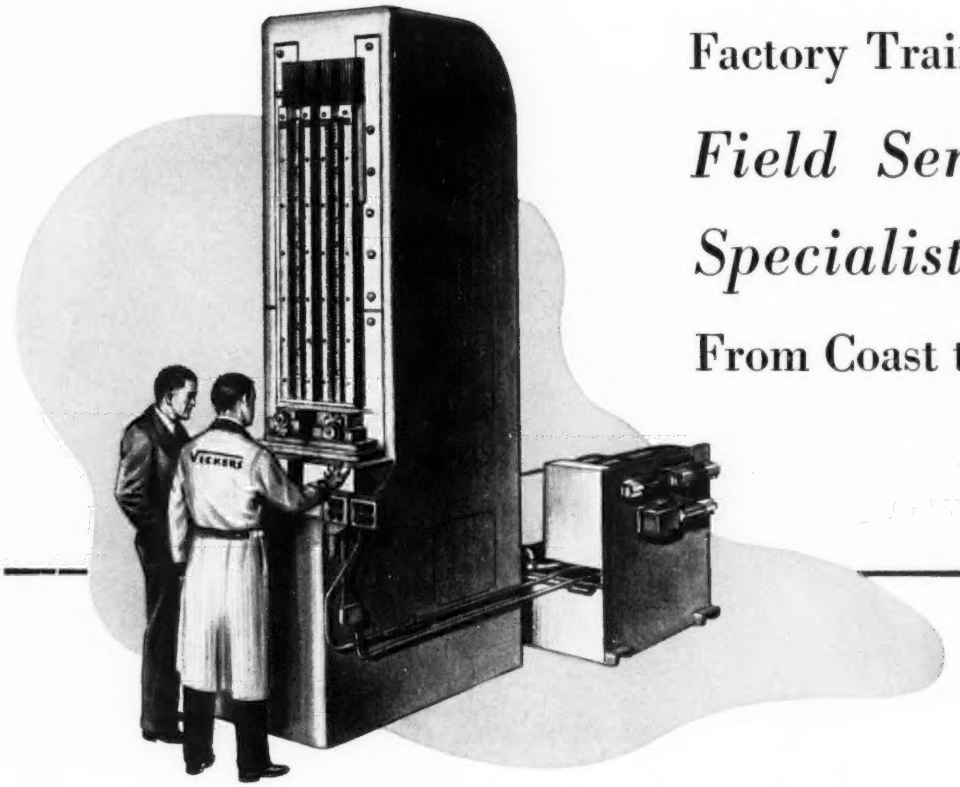
Hyatt's complete line of radial and angular-contact bearings—*more than 800 sizes in the Hy-Load series alone*—makes the engineers' job easier, because it makes possible greater design flexibility. For the equipment *buyer*, this means longer bearing life and lower maintenance costs—with just the right bearings designed into every vital load-carrying position.

The next time you buy new equipment, or make a changeover, *specify lower maintenance costs by specifying Hyatt Bearings!* And if you need technical help in your selection of bearings, or desire information about particular bearings or their applications, ask for the services of a Hyatt sales-engineer. Call or write Hyatt Bearings Division, General Motors Corp., Harrison, N. J.

HYATT BEARINGS DIVISION • GENERAL MOTORS CORPORATION

ONE OF A SERIES

You Get Many Benefits by Specifying VICKERS® Hydraulics



Factory Trained *Field Service Specialists* From Coast to Coast

All machinery made by man requires servicing at times. Every manufacturer has two responsibilities: First, to build his equipment in a way that will require the least amount of servicing. Second, to see to it that servicing, when needed, is handled with speed, efficiency and low cost.

Vickers hydraulic equipment is built to keep service requirements to an irreducible minimum. But when service is required, it is handled by Field Service Specialists working out of Vickers offices from coast to coast. These men have been carefully trained in Vickers plants and are thoroughly competent. They know how to adjust and maintain any piece of Vickers equipment . . . any combination of components. They are also qualified to instruct customers' service organizations in improving their hydraulic maintenance practices. These men devote their full time to servicing Vickers products in customers' plants. They do their job well and at minimum expense.

This is only one of many benefits you receive when you specify Vickers Hydraulics.

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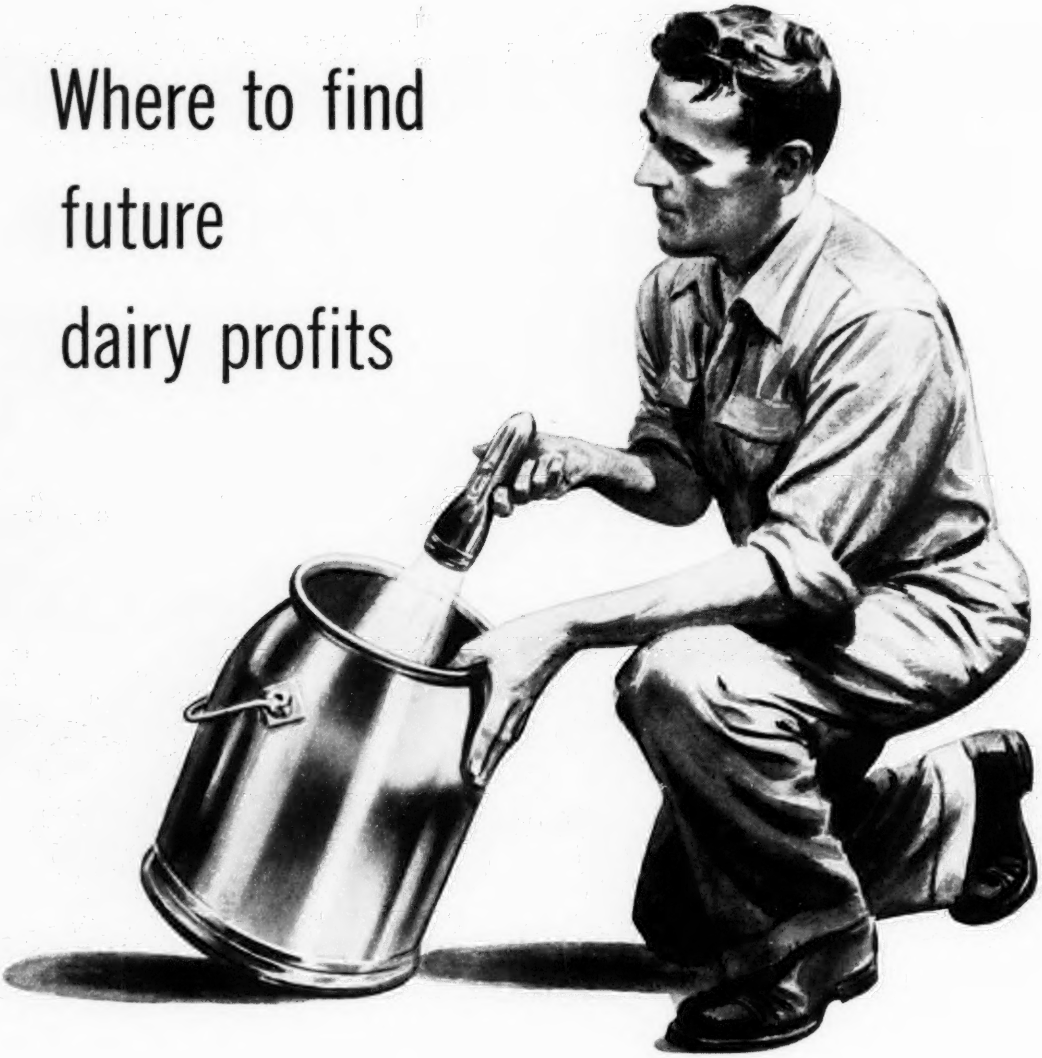
6395

ENGINEERS AND BUILDERS OF OIL HYDRAULIC EQUIPMENT SINCE 1921

Where to find future dairy profits



Farmers will find steady dairy profits in the gleaming, easy-to-clean surface of Armco Stainless Steel.

Stainless Steel is rustless all the way through, with no surface plating to wear off or peel and catch bacteria. So stainless steel milker pails, tanks, strainers and other equipment in dairy barns make it easy for farmers to meet highest sanitary regulations. This brings top prices for milk.

Because stainless steel never needs replating or maintenance other than simple cleaning, it costs much less in the long run. It will still be good as new long after equipment made of other materials has to be replaced.

Armco Stainless Steel is one of many Armco Special-Purpose Steels designed especially to give longer, better service. Look for the Armco triangle trademark. It is your assurance of top metal quality.

ARMCO STEEL CORPORATION

MIDDLETOWN, OHIO • THE ARMCO INTERNATIONAL CORPORATION WORLD-WIDE

ARMCO

THE WORLD-FAMOUS AETNA T-TYPE CLUTCH RELEASE BEARING

Plus VALUE FEATURES

• T-shaped oil-impregnated bronze ball separator maintains perfect concentricity—eliminates eccentric thrust, excessive wear—assures the plus smoothness, quietness and endurance of bronze-to-steel contact.

• Large, factory-packed grease reservoir assures lifetime lubrication—no need for costly grease fittings or oil lines.

• Special construction locks shell to free race, forming leak-proof joint. Lubricant can't escape to clutch facings, never needs replenishment.

• Case hardened races for wear-resistant working surface and tough, elastic, shock-absorbing core.

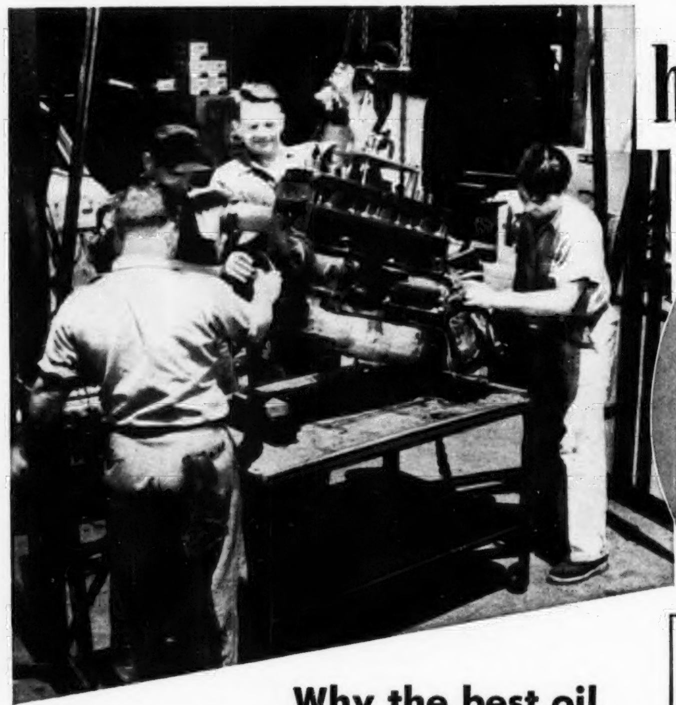
Standard and Special Ball Thrust Bearings • Angular Contact Ball Bearings • Special Roller Bearings • Ball Retainers • Hardened and Ground Washers • Sleeves • Bushings • Miscellaneous Precision Parts.

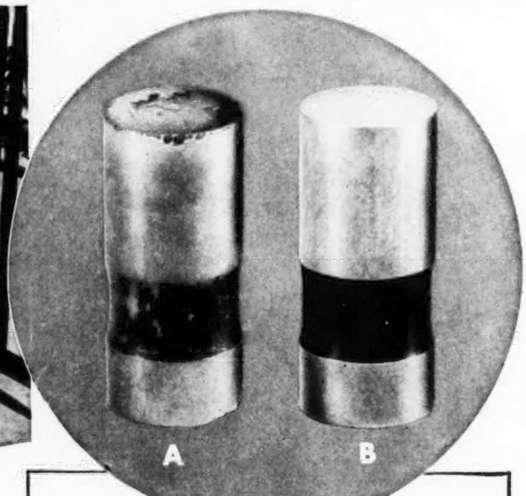
In 1953, as in the past 19 years more of the nation's mobile vehicles will be equipped with the Aetna T-Type clutch release bearing than with any other type. Its unrivaled service life has always made it the most economical in the long run. Once installed it is trouble-free, attention-free for vehicle life. Thanks to its design and lubricant capacity there's no need of costly machining operations for oil lines or grease fittings—no need for further maintenance whatsoever. Think what that saves in man and machine hours on the assembly line, in saving up-keep costs for the vehicle owner.

It's a trusty sign of dependability and economical performance in any vehicle—the famous Aetna T-Type bearing. Investigate. Find out the many other sound reasons it deserves a place in your specifications.

AETNA BALL AND ROLLER BEARING COMPANY
4600 Schubert Avenue • Chicago 39, Illinois

A BETTER Motor Oil had to be BUILT





Why the best oil Mother Nature could offer had to be MADE BETTER

The need for a motor oil better than the best nature could offer came with today's high-speed, super-powered engines.

Tests of conventional oil with these modern power plants revealed wear so great it could be seen with the unaided eye — *a better motor oil had to be built.* And Texaco built it — the greatest oil ever available to motor owners — *Advanced Custom-Made Havoline.*

In formulating it, we first made the best oil superior refining could produce. Then — by a Balanced-Additive formula — *made it better,* built a motor oil so advanced in anti-wear qualities that it actually wear-proofs engines. It keeps engines clean, protects against sludge, rust and bearing-eating acids.

Give your car, truck, tractor and Diesel engines the greater protection of *Advanced Custom-Made Havoline.* Get Havoline from your Texaco Man or your nearby Texaco Dealer.

The BEST OIL is MADE ...not BORN

You can see the difference Havoline's Balanced-Additive formula makes in engine wear. Note the "soup bowl" worn in valve lifter "A" after only 100 hours' operation with a good non-additive oil. Note the like-new condition of valve lifter "B" after *500 hours* with *Advanced Custom-Made Havoline.*

THE TEXAS COMPANY

IT PAYS TO FARM WITH
TEXACO PRODUCTS

DIVISION OFFICES: Atlanta 1, Ga.; Boston 17, Mass.; Buffalo 3, N. Y.; Butte, Mont.; Chicago 4, Ill.; Dallas 2, Tex.; Denver 5, Colo.; Houston 1, Tex.; Indianapolis 1, Ind.; Los Angeles 15, Calif.; Minneapolis 3, Minn.; New Orleans 12, La.; New York 17, N. Y.; Norfolk 1, Va.; Seattle 11, Wash.

Texaco Petroleum Products are Manufactured and Distributed in Canada by McColl-Frontenac Oil Company Limited.

TUNE IN... Metropolitan Opera broadcasts every Saturday afternoon beginning December 5. See newspaper for time and station.

Need low cost, quick assembly, long bearing life?

here's how manufacturers of automotive components

get them with **NEEDLE BEARINGS**

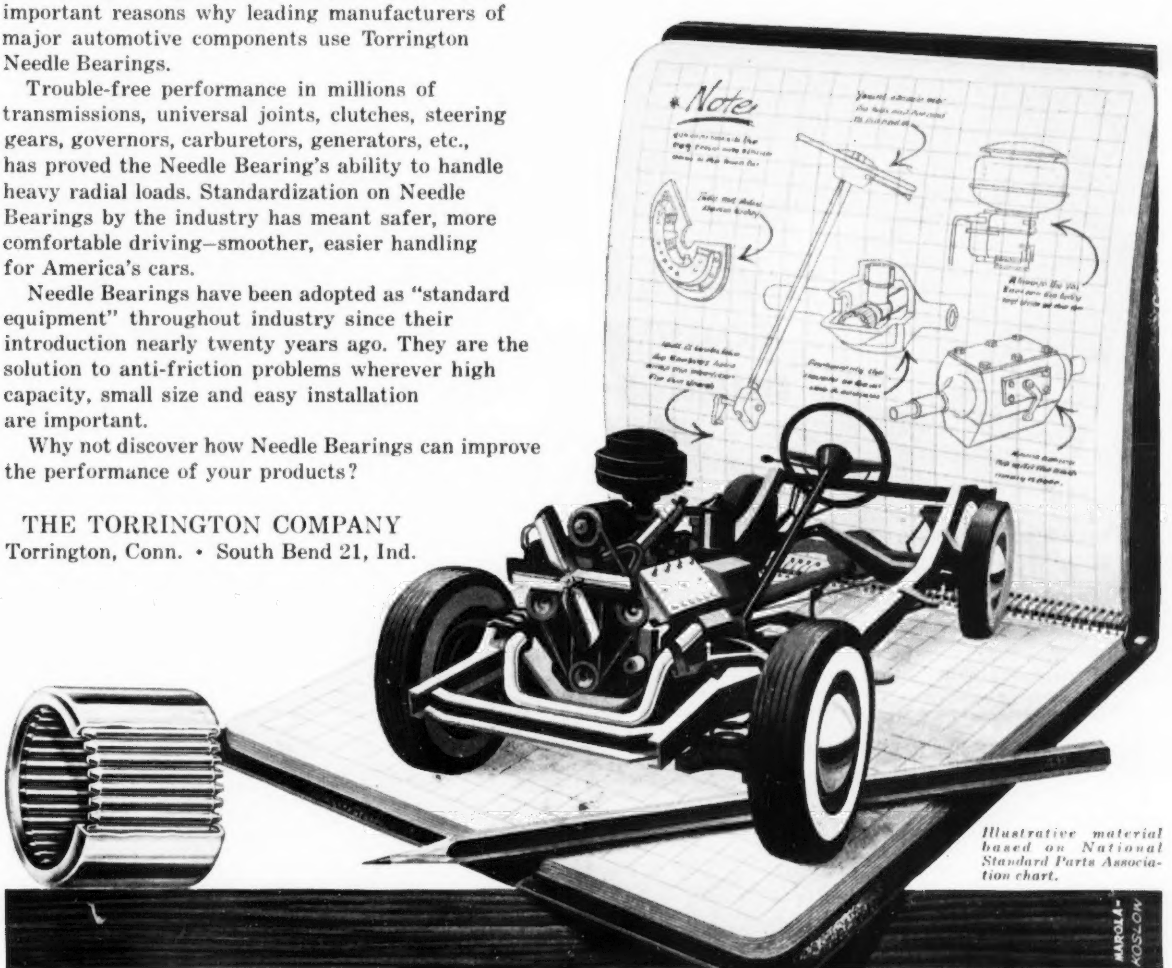
Low initial cost and ease of installation are two important reasons why leading manufacturers of major automotive components use Torrington Needle Bearings.

Trouble-free performance in millions of transmissions, universal joints, clutches, steering gears, governors, carburetors, generators, etc., has proved the Needle Bearing's ability to handle heavy radial loads. Standardization on Needle Bearings by the industry has meant safer, more comfortable driving—smoother, easier handling for America's cars.

Needle Bearings have been adopted as "standard equipment" throughout industry since their introduction nearly twenty years ago. They are the solution to anti-friction problems wherever high capacity, small size and easy installation are important.

Why not discover how Needle Bearings can improve the performance of your products?

THE TORRINGTON COMPANY
Torrington, Conn. • South Bend 21, Ind.



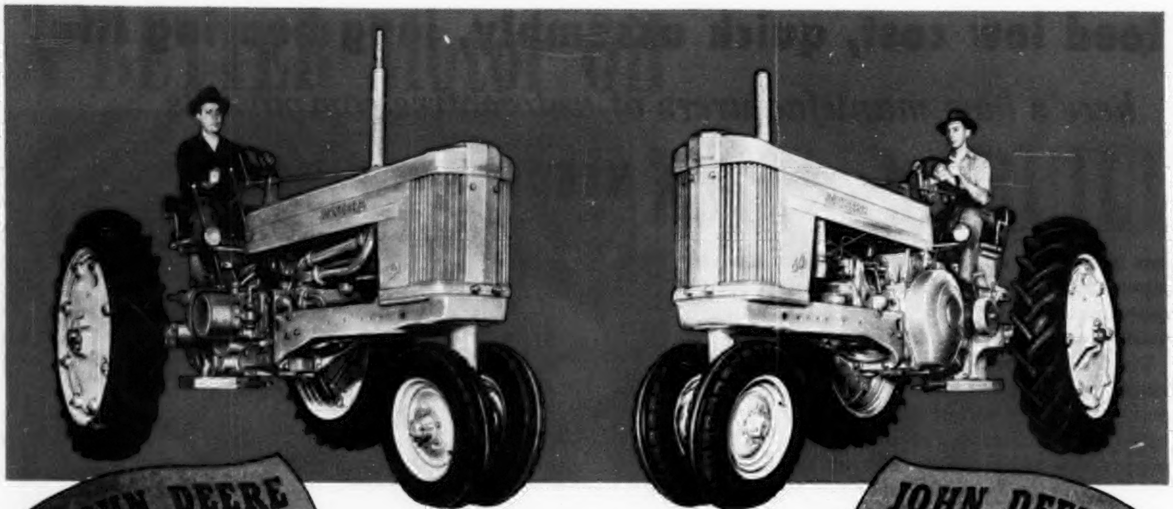
Illustrative material based on National Standard Parts Association chart.

TORRINGTON NEEDLE BEARINGS

Needle • Spherical Roller • Cylindrical Roller • Tapered Roller • Ball • Needle Rollers

Trade marks of some of the leading automotive component manufacturers whose products enjoy the benefits of Needle Bearings.

DETROIT UNIVERSAL JOINTS · STEWART-WARNER · HUPPOWER UNITED ELECTRIC ACTUATING DEVICES · Spicer · DETROIT GEARS · ROCKFORD CLUTCH DIVISION · GEMMER MANUFACTURING COMPANY · CLEVELAND UNIVERSAL JOINTS · WARNER GEAR CO. · KS · The Accepted DA Standard



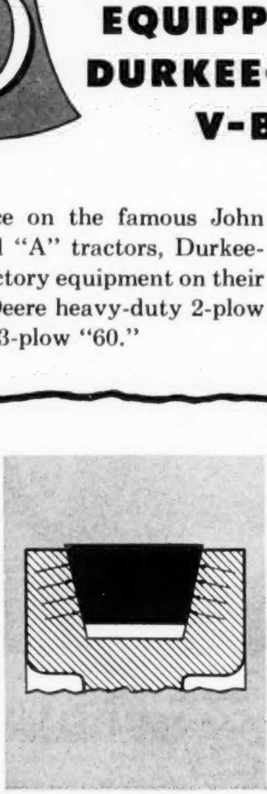
THESE HUSKIES ARE EQUIPPED WITH DURKEE-ATWOOD V-BELTS

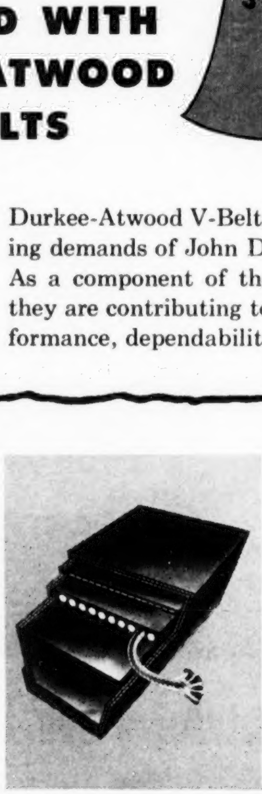
Proved in field service on the famous John Deere Model "B" and "A" tractors, Durkee-Atwood V-Belts are factory equipment on their successors, the John Deere heavy-duty 2-plow "50" and heavy-duty 3-plow "60."

Durkee-Atwood V-Belts are meeting the exacting demands of John Deere Tractor engineers. As a component of the new "50" and "60," they are contributing to their outstanding performance, dependability and efficiency.

STRAIGHT SIDEWALLS MAINTAIN FULL GROOVE CONTACT

Durkee-Atwood V-Belts are manufactured with straight sidewalls to maintain full groove contact at all times giving positive drive action. Straight sidewalls reduce slippage and assure smooth, efficient power transmission. The load is distributed evenly over the entire thickness of the belt giving it longer life.





DU PONT "CORDURA"® RAYON CORDS ARE USED FOR D-A V-BELTS

Cords of high-tenacity "Cordura"® Rayon give Durkee-Atwood V-Belts longer life, less stretch, and greater shock resistance. Use of this revolutionary new cord material is a noteworthy contribution to their improved performance.

DURKEE ATWOOD V-BELTS

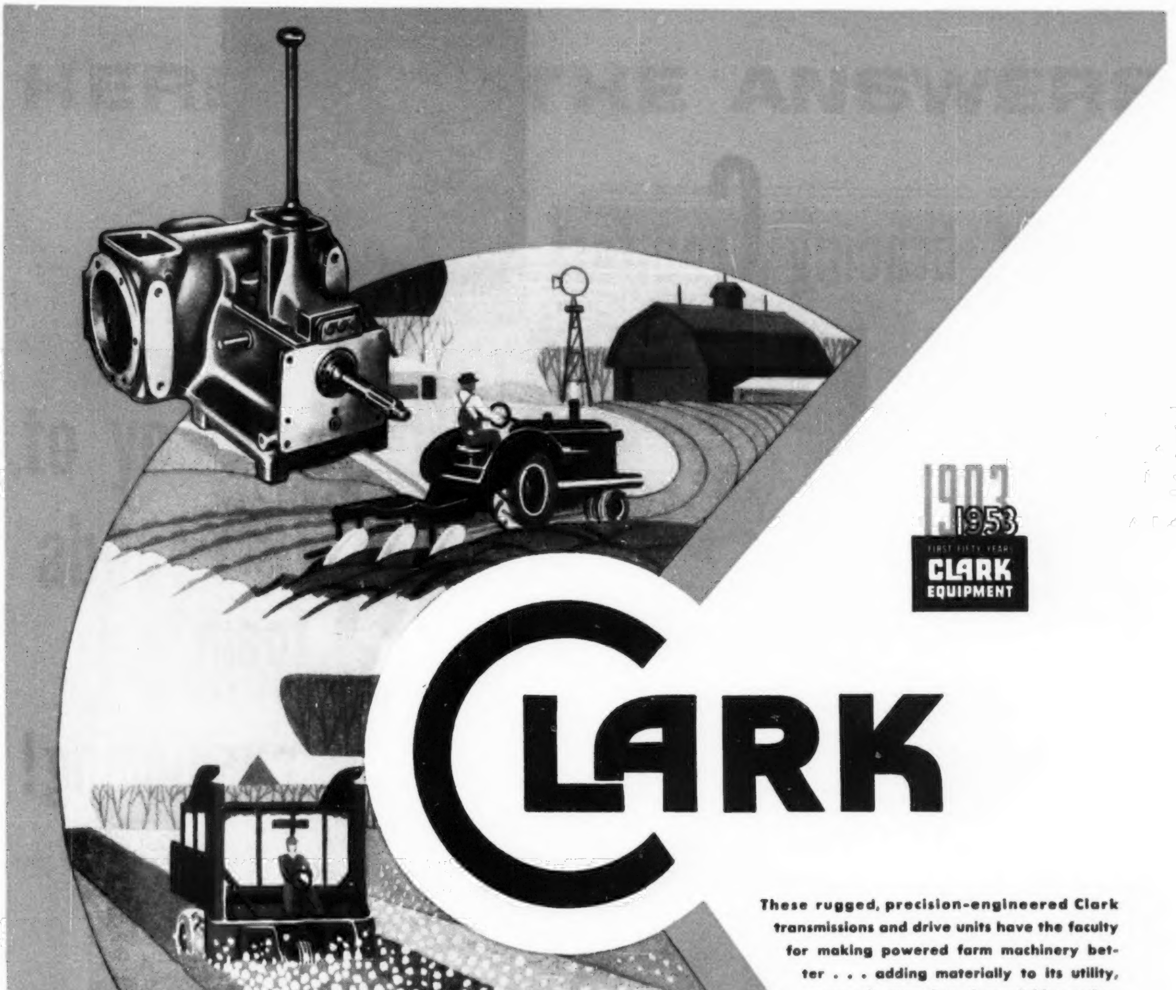
Form No. 557

DURKEE-ATWOOD CO.

Dept. AE-12 Minneapolis 13, Minn.

Suppliers of original equipment V-Belts for major manufacturers of:

TRACTORS • COMBINES • MOWERS • HAY RACKS • FORAGE HARVESTERS
CORN PICKERS • WINDROWERS • CHOPPERS • COTTON PICKERS


1903 1953
FIRST FIFTY YEARS
CLARK
EQUIPMENT
CLARK
These rugged, precision-engineered Clark transmissions and drive units have the faculty for making powered farm machinery better . . . adding materially to its utility, ease of operation, dependable performance and useful life. Perhaps that's why so many manufacturers have long since learned that "it's good business to do business with CLARK."
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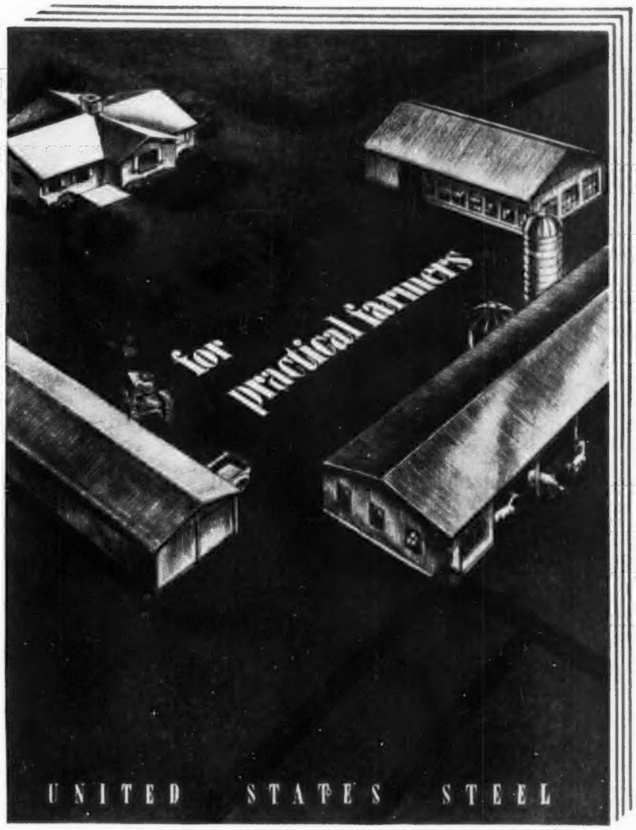

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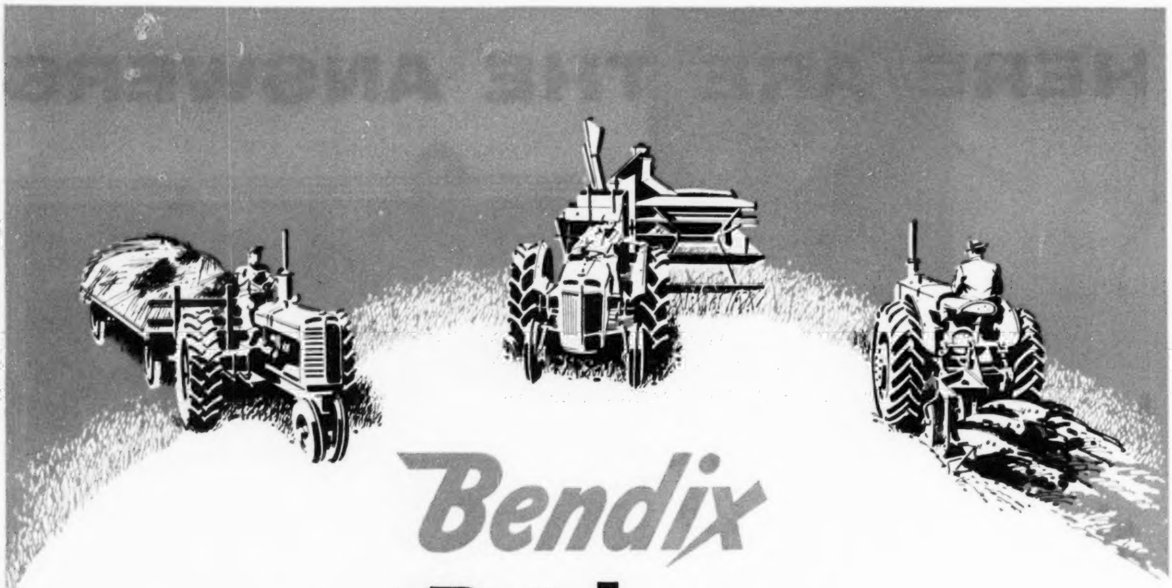

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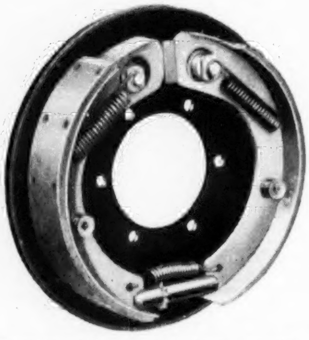

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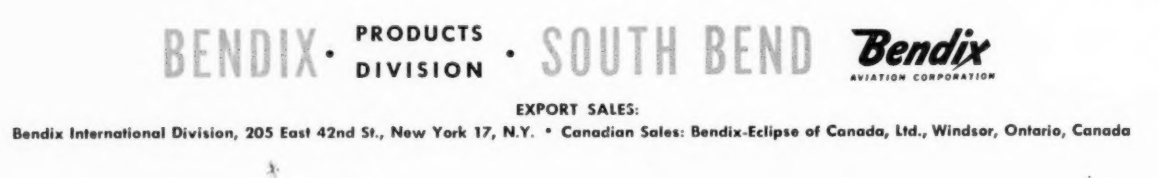

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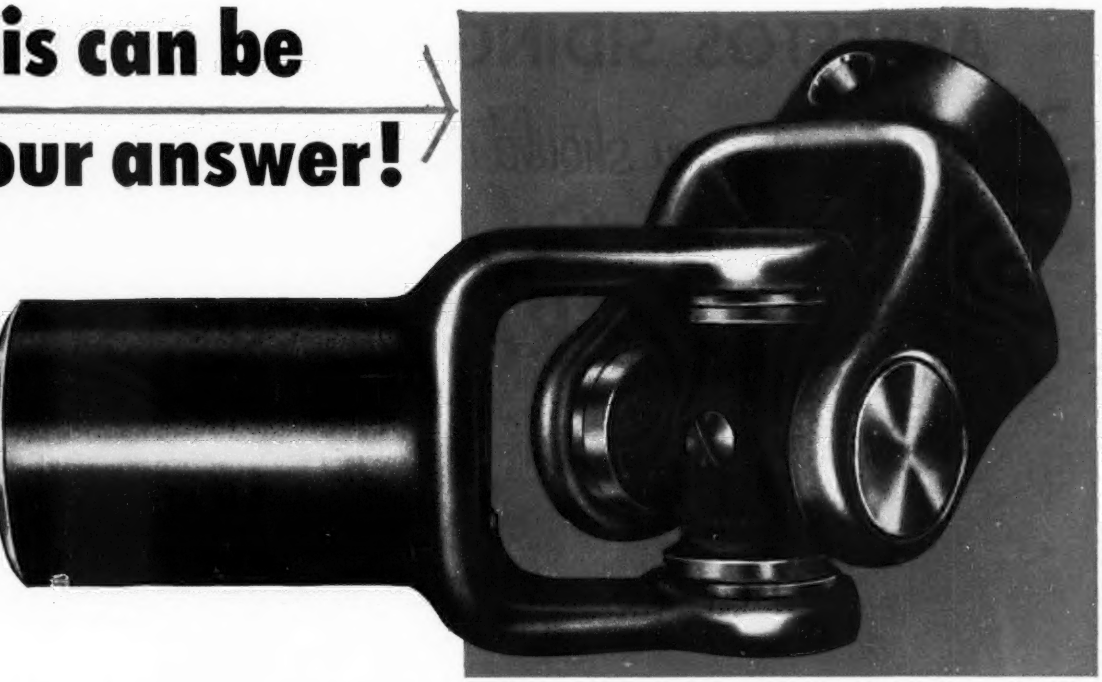

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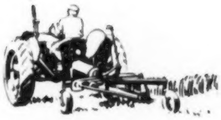

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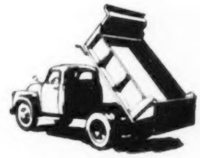

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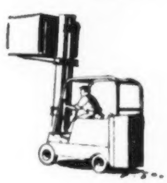

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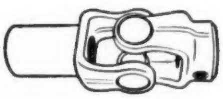

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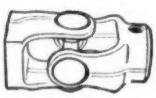

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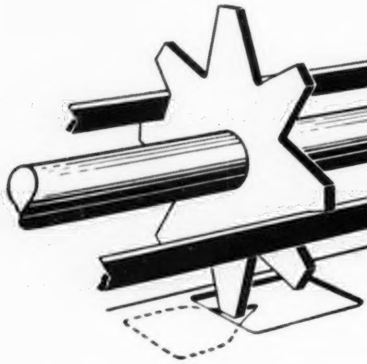

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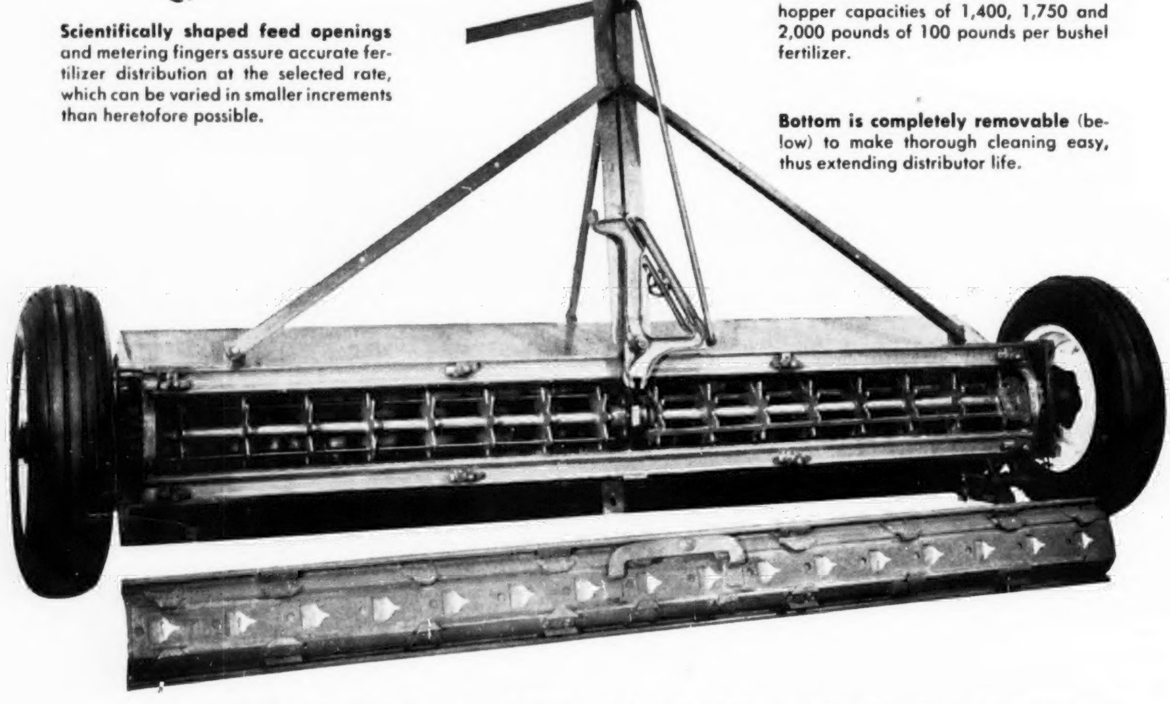

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AGRICULTURAL ENGINEERING

VOL. 34 DECEMBER, 1953 No. 12

An Analysis of Basic Factors Affecting Ventilation Equilibrium

W. J. McGoldrick, Jr.
ASSOC. MEMBER ASAE

THIS paper is an analysis of the basic factors affecting ventilation equilibrium in a dairy barn or poultry house. The analysis was prepared for the purpose of simplifying the mathematical approach to ventilation equilibrium by solving the equations graphically or with an analog computer — in other words, of developing a tool in the form of a composite graph or analog computer which can be used to work equilibrium problems in dairy barn or poultry house ventilation.

The graphic approach will constitute the first part of the paper, the analog computer the second, and a study of ventilation controls the third.

All the basic factors affecting equilibrium, such as heat and moisture production by the animal, water evaporated from floors and gutters, decomposition heat, solar heat, and etc., are treated as independent variables. This has been done because of the variation in animal size and breed, geographical location, and lack of agreement between authorities.

In working with the graphic analyzer or computer, generally all the variables, except two, must be known or assumed. The analyzer or computer is flexible in that any two of the variables may be the unknowns. The exception is where the two unknown variables appear in one equation and not in the other.

This paper was presented at the annual meeting of the American Society of Agricultural Engineers at Pittsburgh, Pa., June, 1953, as a contribution of the Farm Structures and Rural Electric Divisions.

The author — W. J. McGoldrick, Jr. — is research engineer, Minneapolis-Honeywell Regulator Co.

GRAPHIC SOLUTION TO VENTILATION HEAT AND MOISTURE BALANCE EQUATIONS

This graphic analysis of the equilibrium equations consists of making a composite graph which includes all the factors in the given equation in such an order that one can follow the solution of the equation if all but one of the basic factors are known.

The graphic analysis solution is similar to a nomograph in that an equation is solved by drawing lines from one axis to another, but it does not look like a nomograph with its skew lines and nonparallel lines. Instead, these scales are all linear and curves or straight lines are used as intersection points.

The composite graph (Fig. 1) is made by choosing two variables in the basic heat balance equations and placing them on a graph — one as the abscissa scale and the other as a graph line. If these two factors are to be added or subtracted, the graph lines will be straight and parallel. These two independent variables, when combined, will yield a third dependent variable which will be the ordinate scale. This dependent variable will in turn be the ordinate scale of an adjoining graph in which another variable may be added, subtracted, or divided, which will yield a second dependent variable. Thus, additions, subtractions, and divisions may be carried out across the graph page to form a composite graph.

There are two equations to be solved in animal-shelter ventilation. The heat balance equation solution is on the left side of the graph and the moisture balance solution is on the right. The heat and moisture balance equations

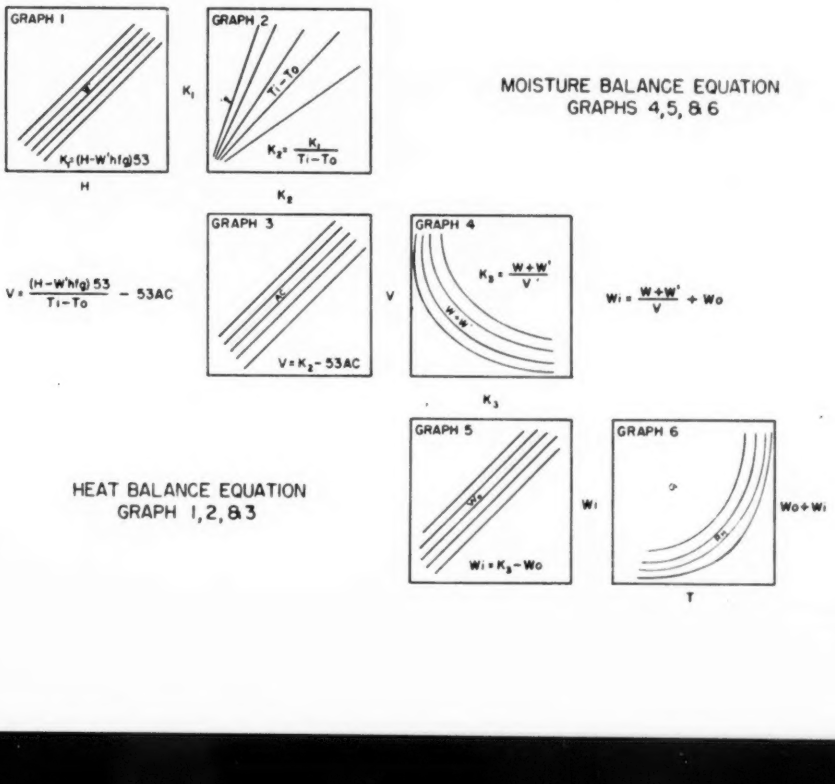


Fig. 1 Composite graph for the solution of heat balance and moisture balance equations

were solved for the common factor V (air exchange of the building), and the two equations and graphs were placed back to back with V as the common ordinate scale, so that upon completion of the solution to one equation one would be able to pass into the other equation for solution.

A simpler explanation of the composite graph is to say that it is made up of many individual graphs placed in such a manner that one can go from one graph to the next, and in doing so complete the solution to the equation.

The graphic solution for a dairy barn is on a per cow basis and is shown in Fig. 2. The poultry house graphic solution is shown in Fig. 3 and is on a 50-bird-per-unit basis. In both diagrams there is an inset in the upper right-hand corner showing an example problem.

Graphic Analysis of Dairy Barn Ventilation

This analysis of dairy barn ventilation consists of a graphic solution of the heat and moisture balance equations such that the volume factor (V) in cfh is common to both solutions.

It is not correct to assume that the volume in cfm of air discharged is the same as that volume brought into the building, but the error involved in doing so is not significant considering the probable accuracy of the data.

Heat Balance Equation

$$H = W''h_{fg} + AC\,(t_i - t_o) + V/53\,(t_i - t_o) \quad [1]$$

where H = sensible heat produced by a cow in Btu per hr

$W''h_{fg}$ = heat required to evaporate W'' lb of water from the floors and gutters

$AC\,(t_i - t_o)$ = heat loss through the walls of the barn

$V/53\,(t_i - t_o)$ = heat removed by air exchange.

Moisture Balance Equation

$$W' + W'' = V(w_i - w_o) \quad [2]$$

where $W' + W''$ is the water vapor generated in the structure, and $V(w_i - w_o)$ is the water vapor removed by air exchange*.

H = Btu of sensible heat produced by a cow in one hour

W'' = pounds of water vapor evaporated from floors and gutters per hour per cow

h_{fg} = heat of vaporization

A = area of wall surface exposure per cow in ft²

C = weighted average of conductance of exposed wall in Btu per hr per 1 deg F per ft²

t_i = inside temperature in deg F

t_o = outside temperature in deg F

V = ventilation rate in cfh

$1/53$ = Btu required to raise 1 cu ft of air 1 deg F

W' = pounds of water vapor expelled by a cow in one hour

w_i = water vapor content of inside air in lb per cu ft

w_o = water vapor content of outside air in lb per cu ft

*Air exchange includes infiltration rate when the fan is not running.

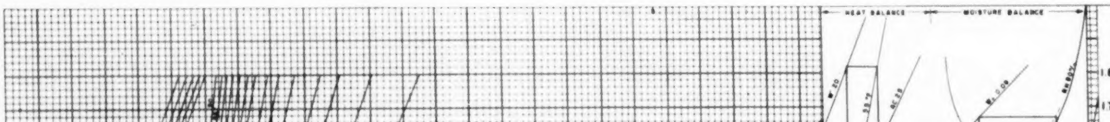


Fig. 2 This diagram illustrates the graphic solution of the heat and moisture balance in a dairy barn

Solving for V in the heat balance equation,

$$V=\frac{(H-W''h_{fg})\,53}{t_i-t_o}-53\,AC \quad . \quad . \quad . \quad . \quad . \quad [3]$$

Following Fig. 1, setting $K_1=(H-W''h_{fg})\,53$. [4]

(For graph 1 with H as the abscissa scale, $W''h_{fg}$ as diagonal lines, and K_1 as the ordinate scale.)

Then equation [3] becomes

$$V=(K_1/t_i-t_o)-53\,AC$$

Setting $K_2=(K_1/t_i-t_o)$ . . . . [5]

(For graph 2 with K_1 as the common ordinate scale with graph 1, t_i-t_o as diagonal lines, and K_2 as the abscissa scale.)

Then equation [3] becomes

$$V=K_2-53\,AC \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad [6]$$

(For graph 3 with K_2 as the common abscissa scale with graph 2, AC as diagonal lines, and V as the ordinate scale.)

Solving for w_i in the moisture balance equation,

$$w_i=(W'+W''/V)+w_o \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad [7]$$

Setting $K_3=(W'+W''/V)$ . . . . [8]

(For graph 4 with V as the common ordinate scale with graph 3, $W'+W''$ as curved lines, and K_3 as the abscissa scale.)

Then equation [7] becomes

$$w_i=K_3+w_o \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad [9]$$

(For graph 5 with K_3 as the common abscissa scale with graph 4, w_o as diagonal lines, and w_i as the ordinate scale.)

Graph 6 is not a part of the solution to the equation but is a psychrometric graph which shows the relationship between (w, t, and RH), and is so set up that the w scale is the common ordinate to the w_i scale in graph 5. Thus upon completion of the solution of the equation one can read RH (relative humidity) by passing directly into graph 6 from graph 5. Graph 6 is also used to determine the value of w_o to substitute in graph 5.

From the appendix to this paper, the inside temperature, relative humidity, and the critical U value may be found which indicate to what extent the wall must be insulated to prevent condensation for a given set of conditions.

Example 1. To find the allowable heat loss factor (AC value) in Btu per hour per cow per degree Fahrenheit difference between the barn temperature and outside temperature when the design conditions are the following:

$H=3000$ Btu per hr per cow and $W'=0.5$ lb water vapor produced per hour per cow

$W''=0.20$ lb water vapor evaporated from floor and gutter per hour per cow†

Outside air conditions—$t_o=0$ F; $RH_o=100$ percent

Inside air conditions—$t_i=55$ F; $RH_i=85$ percent‡.

†H. J. Thompson and R. E. Stewart: Water vaporized from surfaces under cow average between 0.375 and 0.542 lb per hr per cow. AGRICULTURAL ENGINEERING, vol. 33, p. 206, April, 1952.

‡From the appendix to this paper the inside allowable relative humidity was determined by assuming that the critical U value of the barn was $U=0.15$.

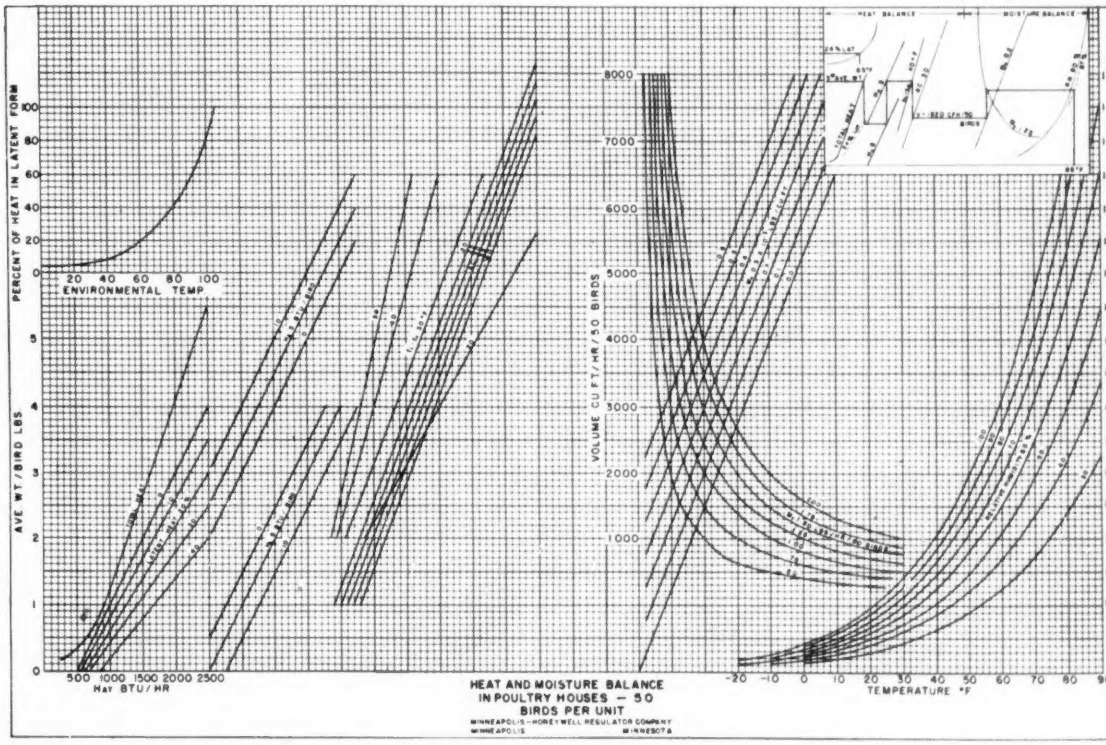


Fig. 3 This diagram illustrates the graphic solution of the heat and moisture balance in a poultry house, on a 50-birds-per-unit basis

Solution. The solution consists of working forward (Fig. 1) from the heat balance side of the graph up to graph 3 and working backwards from the moisture balance side of the graph to graph 3, so that the intersection of both lines on this plot will determine the necessary AC value. The graphic solution is shown in the upper right-hand corner of Fig. 2 with lines and points of intersection.

A vertical line is drawn up from the sensible heat scale, $H=3000$ Btu per hour per cow to the intersection of the diagonal $W'=0.20$ lb per hour per cow line. Then a horizontal line is drawn from this intersection over to the $(t_i-t_o)=55$ F line. A vertical line from this point drawn downward will intersect all values of AC. To find the ordinate which must intersect this vertical line so that a particular value of AC is determined, one must begin on the moisture balance side and work backwards. Locate the inside temperature, $t_i=55$ F, on the temperature scale of the psychrometric chart and draw a vertical line upward to the curved line which represents the inside relative humidity $RH_i=85$ percent. From the intersection a horizontal line is drawn to the intersection of the outside absolute humidity which is a diagonal line $W'_o=0.08\times10^{-3}$ lb per cu ft. From this intersection a vertical line is drawn to the curved line $W'+W''=0.7$ lb per hr per cow. A horizontal line from this point will intersect all values of AC. Where the horizontal line intersects the vertical line, brought down from the t_i-t_o intersection, the proper AC value is determined for this particular problem. In this case the intersection occurred at an AC value of 25.

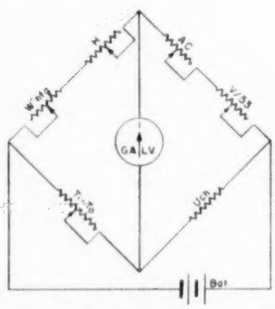
The horizontal line brought over from the $W'+W''=0.7$ lb per hr per cow also determines the ventilation rate for the specified temperature in that the horizontal ventilation rate scale was intersected at $V=1350$ cfh.

In the event that the outside temperature should fall below the design temperature, there are four ways one can prevent condensation from occurring on the walls. The first way is to diminish the heat loss of the building by adding insulation, such as wall fill, storm windows, double doors, etc. The second way is to increase the supply of heat to the building by either increasing the number of animals, tempering the intake air by passing it through the loft, adding a heat exchange to the exhaust air, or generating heat from a fuel source. The third way is to use slot intakes so that the intake air passes over the surfaces of the walls before or as it mixes with the inside air. The object of the slot intakes is to lay a layer of intake air over the walls so that the warm moist room air does not come in contact with the wall and condense. This method of preventing condensation seems promising, but as yet has not been used widely enough to determine its practicability. The fourth way is to change the thermostatic setting which controls the exhaust fan. If the barn is well insulated, the thermostatic setting may be increased to prevent condensation, and in a poorly insulated barn it will have to be decreased.

Increasing the thermostatic setting for the well-insulated barn decreases the volume of air being discharged by the fan, but the amount of water vapor being removed is increased because the discharge air is at a higher temperature and is holding much more water for the same relative humidity. As the insulation properties of the barn diminish, this situation becomes defeated for three reasons. The first is that too high a proportion of the heat will be lost through the walls when the temperature difference between inside and outside is high, so that the fan must slow down too much to conserve heat, and consequently not enough moisture will be removed even though the air is holding more water per unit than previously. The second reason which defeats this situation is that the allowable relative humidity inside decreases as the inside temperature increases. The third reason is that condensation and frost will form more rapidly on the windows and cracks as the inside absolute humidity increases.

Graphic Analysis of Poultry House Ventilation

The graphic analysis of poultry house ventilation is very similar to that of the dairy barn analysis, except for the following exceptions. Mitchell and Kelley's graph (Fig. 3) showing total heat versus bird size is introduced at the beginning of the solution, and also their graph showing percent of heat in latent form versus ambient temperature is inserted in the upper left-hand corner. No subtraction of sensible heat is carried out as it is assumed that heat from litter decomposition is in excess of that needed to keep the litter moisture content stable. Two additional sources of heat are included, namely, from litter decomposition and from solar heat. It is assumed that the water consumption of the birds minus the water removed in taking out the eggs is the amount of water that the ventilation system is required to remove after the difference in relative humidity between inside and outside has been taken into account. The poultry analysis is done on a 50-bird-per-unit basis rather than on a single-animal basis as in the dairy barn.



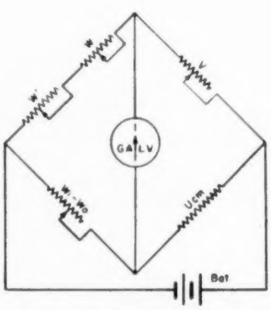
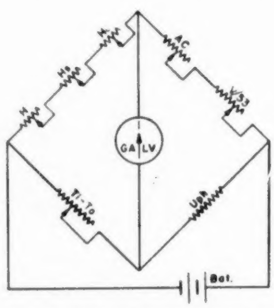


Fig. 4 *(Left)* Components of the dairy barn heat balance equation substituted in the legs of a Wheatstone bridge • Fig. 5 *(Right)* Components of the dairy barn moisture balance equation substituted in the legs of a Wheatstone bridge



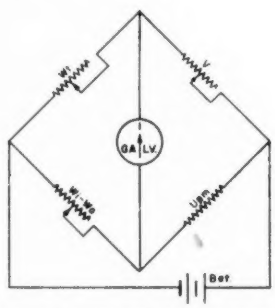


Fig. 6 *(Left)* Components of the poultry house heat balance equation substituted in the legs of a Wheatstone bridge • Fig. 7 *(Right)* Components of the poultry house moisture balance equation substituted in the legs of a Wheatstone bridge

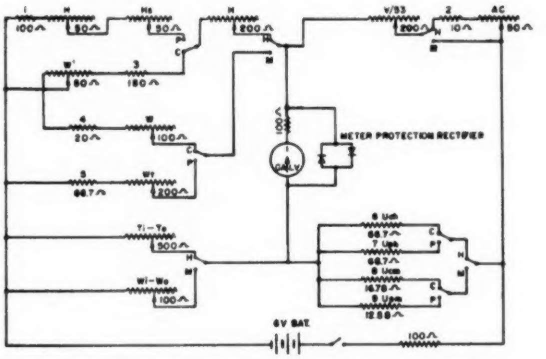


Fig. 8 Circuit diagram for a combination heat and moisture balance computer for both dairy barn and poultry house ventilation solutions

Heat Balance Equation

$$(H_{AT}-H_{lat})+H_L+H_S=AC\ (t_i-t_o)+V/53\ (t_i-t_o) \quad [1]$$

where H_{AT} = total heat given off by the respiratory system and body of the bird

H_{lat} = that portion of the total heat given off by the bird which is in the latent form

H_L = sensible heat given off by litter decomposition (that is, portion of heat from litter decomposition in excess of that used to vaporize the moisture in the litter)§

H_S = solar heat given up to the house through the windows (heat from equipment such as lights and brooders could be added to this factor)

$AC\ (t_i-t_o)$ = heat loss through the walls of the house

$V/53\ (t_i-t_o)$ = sensible heat loss removed by air exchange.

§It is assumed that the litter moisture content is at equilibrium.

Moisture Balance Equation

$$W_T=V\ (w_i-w_o) \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad [2]$$

where W_T = water consumed by birds per hour (water taken out in eggs)

$V\ (w_i-w_o)$ = water vapor removed by air exchange.

Solving for V in the heat balance equation,

$$V/53=\frac{H_{AT}-H_{lat}+H_L+H_S}{t_i-t_o}-AC \quad . \quad . \quad . \quad . \quad [3]$$

The first step is to combine the numerator in the first fraction:

$$H_{AT}-H_{lat}+H_L+H_S=K_1$$

The following is an explanation of the composite graph Fig. 3.

The first curve on the left-hand side of Fig. 3 is Mitchell and Kelley's curve showing total heat (H_{AT}) versus average body weight of bird. Beginning at the left side of Fig. 3, the average weight of the bird is entered on the weight scale and by drawing a horizontal line to the total heat line a value for H_{AT} is found.

From a reproduction of Mitchell and Kelley's graph showing percentage of latent heat versus environment temperature in the upper left-hand corner of Fig. 3, the percentage of the total heat which is in the latent form for a given environmental temperature is determined. A vertical line is then brought down from the (H_{AT}) total heat intersection to the determined percent latent heat line and then horizontally over to the proper (H_S) solar heat line and up vertically to the proper (H_L) litter decomposition line. Thus the available sensible heat K_1 is determined, which is essen-

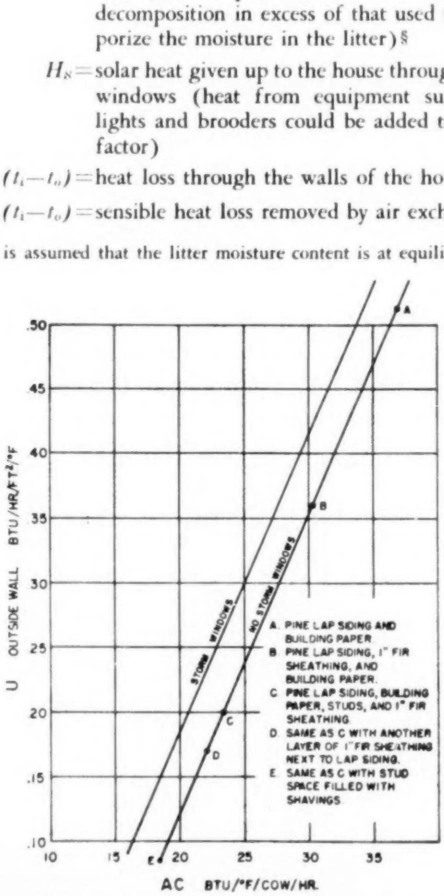


Fig. 9 This graph shows the relationship between AC and the U value for the given barn

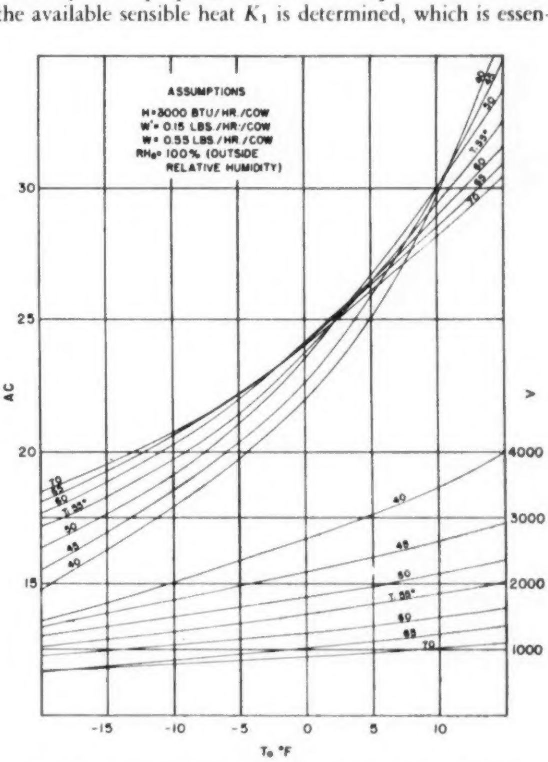


Fig. 10 Curves prepared from the heat and moisture balance graph for dairy barns

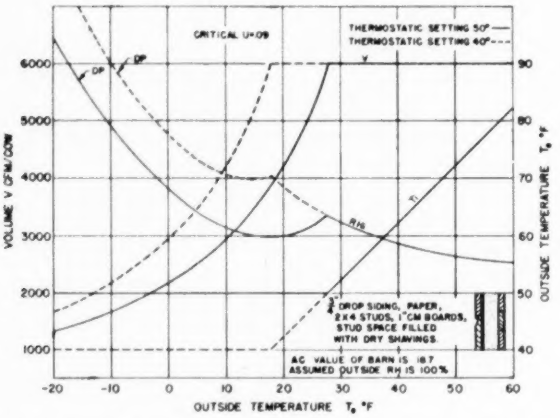


Fig. 11 Graph showing variation of ventilating rate, inside temperature, and relative humidity of barn E, as a function of outside temperature with thermostatic control

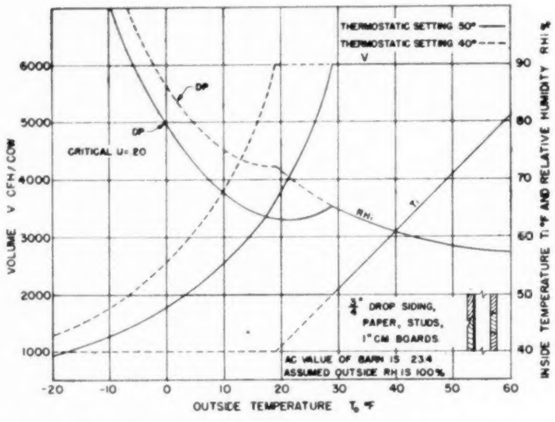


Fig. 12 Graph showing variation of ventilating rate, inside temperature, and relative humidity of barn C, as a function of outside temperature with thermostatic control

tially the same as K_1 in the dairy barn problem. From this point on the solution is the same as that of the dairy-barn analysis. An example problem solution is shown in the upper right-hand corner of the graph.

ANALOG COMPUTER FOR SOLVING VENTILATION HEAT AND MOISTURE BALANCE EQUATIONS

The heat and moisture balance equilibrium equations for dairy and poultry house ventilation lend themselves quite well to the Wheatstone bridge type of computer. The equation will be resolved into the form $X_4/X_2 = X_1/X_3$ in which X_2 is unity.

Dairy Ventilation

Solving the dairy barn heat balance equation for $t_i - t_o$,

$$t_i - t_o = (H - W''h_{fg})/(AC + V/53) \quad . \quad . \quad . \quad . \quad [1]$$

These components are substituted in the legs of a Wheatstone bridge as shown in Fig. 4. The subtraction $H - W''h_{fg}$ is done by assuming that the value of H will not be below some minimum value, and in giving a fraction of this minimum value to the $W''h_{fg}$ potentiometer, the total value of H is decreased as the $W''h_{fg}$ potentiometer is turned clockwise.

Solving the dairy barn moisture balance equation for $w_i - w_o$,

$$w_i - w_o = (W' + W''/V) \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad [2]$$

These components are substituted in the legs of a Wheatstone bridge as shown in Fig. 5.

Poultry House Ventilation

Solving the poultry house heat balance equation for $t_i - t_o$,

$$t_i - t_o = (H + H_L + H_S)/(AC + V/53) \quad . \quad . \quad . \quad [3]$$

where $H = H_{AT} - H_{lat}$.

These components are substituted in the legs of a Wheatstone bridge as shown in Fig. 6.

Solving the poultry house moisture balance equation for $w_i - w_o$,

$$w_i - w_o = W'_T/V$$

where W'_T is the total water consumed by the bird in pounds per hour.

These components are substituted in the legs of a Wheatstone bridge as shown in Fig. 7.

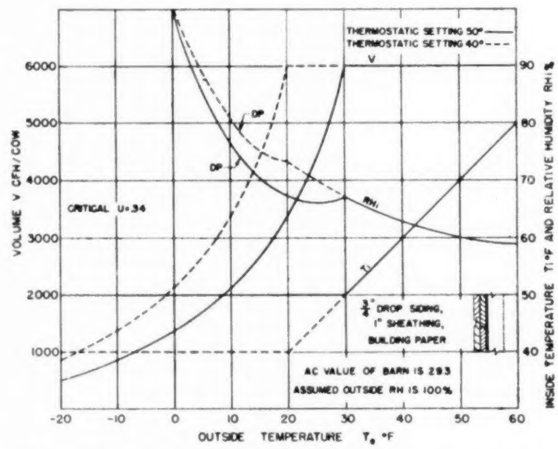


Fig. 13 Graph showing variation of ventilating rate, inside temperature, and relative humidity of barn B, as a function of outside temperature with thermostatic control

Combined Dairy and Poultry Ventilation Computer

The resistances for the potentiometers and unit resistances are chosen such that the components V, AC, and H are common to both dairy and poultry solutions. The V and W'' potentiometers are common to both heat and moisture solutions in the dairy barn ventilation solution. The circuit diagram for a combination heat and moisture balance computer for both dairy and poultry is shown in Fig. 8.

In the electrical diagrams the $(t_i - t_o)$ factor is shown as one potentiometer, but mechanically there are two dials which affect this potentiometer, the inside temperature (t_i) dial and the outside temperature (t_o) dial. This is done by having one dial drive the wiper directly and the other dial rotates the case of the potentiometer through a gear train. This same scheme is used in the case of the $(w_i - w_o)$ potentiometer.

In order that the moisture conditions inside may be read directly in terms of relative humidity, the (t_i) dial drives a wiper horizontally across a small psychrometric chart and the (w_i) dial drives a wiper vertically across the same chart, and where these two wipers cross the relative humidity (RH_i) may be read directly. This same process is used in

determining outside relative humidity there being two windows having psychrometric charts on them, one labelled outside condition and the other labelled inside conditions.

Although there are many switches shown on the electrical diagram, it all boils down to two-dial-positions, four-pole gang switches and one off-on switch.

Standard linear taper wire-wound potentiometers were used in the making of this computer as it was felt that the accuracy of the data available did not justify helical wound potentiometers.

A STUDY OF DAIRY VENTILATION CONTROLS WITH THE AID OF THE ANALOG COMPUTER AND GRAPHIC ANALYZER

The following study is an attempt to analyze some of the ventilation control problems for dairy barns. The primary objective of the ventilation system is assumed to prolong the life of the barn by preventing condensation from occurring on the walls and ceiling. Secondary objectives are to maintain the health of the cow and the comfort of the operator. The problem is difficult to analyze in that (1) there are many variables which affect the atmospheric conditions in the barn, (2) these variables like to change together and in varying properties and (3) the two heat and moisture balance equations must be balanced simultaneously. Essentially the fan is discharging warm moist air from the barn and cold air is entering to replace this through the cracks or designed inlets.

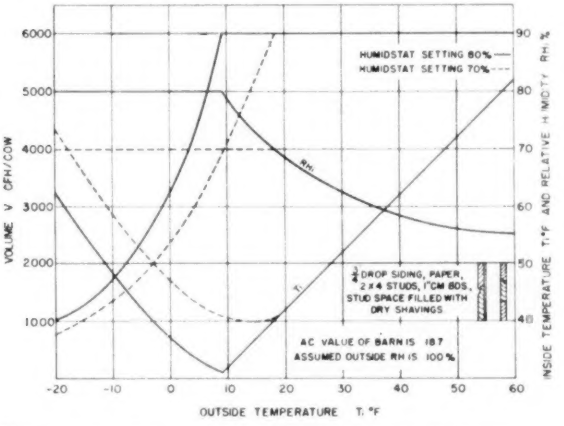


Fig. 14 Graph showing variation of ventilating rate, inside temperature, and relative humidity of barn E, using a humidistat in place of the thermostat to control the fan

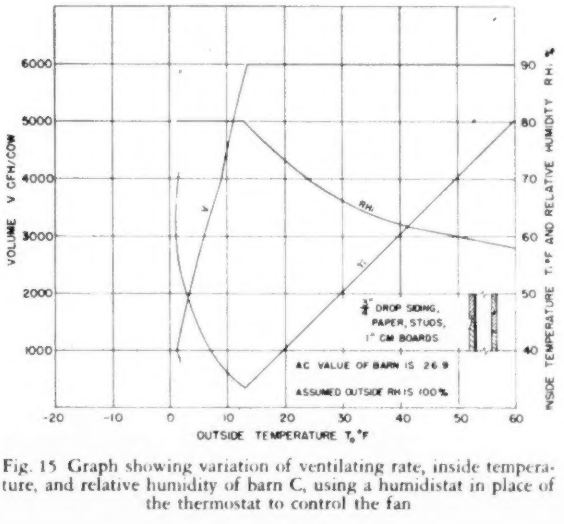


Fig. 15 Graph showing variation of ventilating rate, inside temperature, and relative humidity of barn C, using a humidistat in place of the thermostat to control the fan

Limitations of Controls for Ventilation Fans

Two of the questions most frequently asked concerning the control of dairy barn ventilation are: What temperature should the thermostat be set at under various conditions, and how low may the outside temperature be before a heat exchanger is required for a given barn?

Using the heat and moisture balance graph a set of curves has been prepared (Fig. 10) which help to answer these questions, when the heat and moisture output of the cow is assumed constant over a given range (40 to 70 F) and the animal density is 672 cu ft per cow. These plots gives the relationship between inside and outside temperature for varying insulated barns when the inside relative humidity is at the critical point (allowable *RH* for corresponding temperature and *U* value) and the outside relative humidity is 100 percent.

In preparing Fig. 10, the sensible heat delivered by the cow was assumed to be 3000 Btu per hr, the water evaporated from the floors and gutters to be 0.15 lb per hr per cow, and the water vapor expelled by the cow to be 0.55 lb per hr per cow. The graph shows constant inside temperature lines (t_i) (thermostat settings) plotted against outside temperature (t_o) (design temperature), and barn insulation properties in terms of *AC* where *A* remains constant and *C* is varied.

In determining the allowable inside relative humidity, Fig. 9 was prepared to show the relationship between *AC* and the *U* value for the given barn.

Fig. 10 shows that in order to prevent condensation on the walls in barns with an *AC* property of approximately 25 or less, the thermostat setting should be increased if the outside temperature decreases, while for barns with an *AC* of 25 or greater the thermostat setting should be decreased.

The fact that a lower allowable outside temperature corresponds to a higher inside temperature for *AC* values

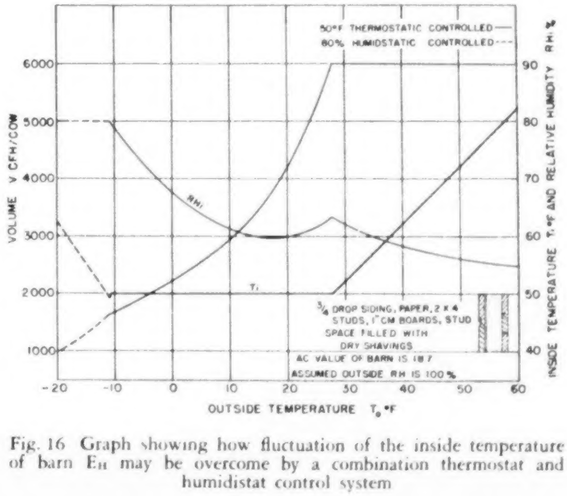


Fig. 16 Graph showing how fluctuation of the inside temperature of barn E_{II} may be overcome by a combination thermostat and humidistat control system

less than 25 may seem inconsistent at first. However, in a well-insulated barn a large proportion of the heat loss is through the ventilation system and if the thermostatic setting is increased the volume of air discharged diminishes slightly but the amount of water vapor removed increases *to a greater extent* because of the increase in absolute water content of the discharged air. In following the 80 percent *RH* line on a psychrometric chart it may be shown that, if the thermostatic setting is increased from 40 to 50 F, the volume of air discharged may be decreased 47 percent before the amount of water expelled will be diminished. Yet it is not necessary to diminish the volume of air discharged this much in a well-insulated barn in order to conserve the heat necessary to maintain this higher temperature.

In a poorly insulated barn, where the *AC* value is above 25, the air taken out by the ventilation system is a smaller portion of the total heat loss. If the thermostat setting is increased, the volume of air discharged must diminish considerably in order to conserve heat because of the large proportion of heat loss through the walls.

For a barn of given *AC* value one may determine from Fig. 10 the outside temperature at which a heat exchanger would be needed. If the *AC* values of the barn is 25, the optimum thermostatic setting is 60 F and the allowable outside temperature is 2 F. If the outside temperature falls below 2 F, a means of saving heat through an exchanger is necessary to prevent condensation.

Types of Control

It is of interest to compare the results obtained by analysis of the ventilation requirements of a well-insulated, double-wall structure (barn E) with a second barn (barn C) which is identical with the first except that the double wall contains no insulation, and also a third barn (barn B) which has but a single wall. The walls are described in Fig. 9.

Assumptions

H = sensible heat give off by a cow, 3000 Btu per hr

W' = water vapor give off by a cow, 0.55 lb per hr per cow

W'' = water evaporated from floors and gutters 0.15 lb per hr per cow

RH_o = relative humidity of outside air is 100 percent.

Conditions

Size of barn 36 x 70. Number of cows in barn—30.

		Wall E		Wall C		Wall B	
	Area, ft²	U	Heat loss, Btu/deg F/hr	U	Heat loss, Btu/deg F/hr	U	Heat loss, Btu/deg F/hr
Wall (7 ft foundation to ceiling)	1288	0.09	116	0.20	258	0.34	437
Foundation (1 ft above floor)	212	0.56	119	0.56	119	0.56	119
Ceiling	2520	0.06	151	0.06	151	0.06	151
Windows	120	1.13	136	1.13	136	1.13	136
Door	76	0.52	40	0.52	40	0.52	40
Total	4216		562		704		883

NOTE: Diagram of wall construction are on the respective graphs. Loft of barns are filled with hay.

$$A = \frac{4216 \text{ ft}^2}{30 \text{ cows}} = 140 \text{ ft}^2 \text{ per cow exposed wall surface}$$

$$C_E = \frac{562 \text{ Btu per deg F per hr}}{4216 \text{ ft}^2} = 0.134 \text{ average heat coefficient for wall of barn E}$$

$$C_C = \frac{704 \text{ Btu per deg F per hr}}{4216 \text{ ft}^2} = 0.167 \text{ average heat coefficient for wall of barn E}$$

$$C_B = \frac{883 \text{ Btu per deg F per hr}}{4216 \text{ ft}^2} = 0.209 \text{ average heat coefficient for wall of barn B}$$

AC_E = 18.7 Btu per deg F per hr per cow heat loss through walls

AC_C = 23.4 Btu per deg F per hr per cow heat loss through walls

AC_B = 29.3 Btu per deg F per hr per cow heat loss through walls

Thermostatic Control of Forced Ventilation

A ventilating fan having a capacity of 6000 cfh per cow is installed in each barn and the thermostat which is controlling the fan is set at 50 F and at 40 F. On Fig. 11 through Fig. 13, when the thermostat is cycling the fan, the lines are solid for a thermostatic setting of 50 F and dashed for a thermostatic setting of 40 F.

Figs. 11, 12 and 13 show the variation of the ventilation rate, the inside temperature, and the relative humidity of barns E, C, and B as a function of outside temperature with thermostatic control. These curves were drawn up with the assumption that the outside relative humidity is 100 percent. If the outside relative humidity is less, as it normally will be, the inside relative humidity will be somewhat less. If the outside temperature is high, the change in relative humidity outside will appreciably affect the inside relative humidity, but we are more concerned with low outside temperatures where a change in outside relative humidity will but slightly affect the inside relative humidity. An example of this is in the case of barn X when the outside temperature is —10 F and the outside relative humidity goes from 100 to 50 percent the inside relative humidity will change from 78 to 74 percent, a change of only 4 percent inside for a change of 50 percent outside. The outside relative humidity plays a more important role in affecting the inside relative humidity in the case of a well-insulated barn over that of a poorly insulated barn.

Barn E_T (Fig. 11). From the diagram in the appendix of this paper, it was determined that condensation would occur on the wall when the outside temperature was —15.5 F for a thermostat setting of 50 F, and at —9 F when the thermostat is set at 40 F. The critical U value (sidewall) was 0.09 and the *AC* value of the barn 18.7.

Barn C_T (Fig. 12). When the thermostat was set for 50 F, condensation would occur on the wall when the outside temperature reached 0 F, and for the thermostat setting of 40 F condensation would occur at 2.0 F outside temperature. The *AC* value for this barn is 23.4 and the sidewall U value is 0.20.

Barn B_T (Fig. 13). For this poorly insulated barn condensation would occur on the wall at approximately 11.5 F for both 50 F and 40 F thermostatic setting. The critical U value is 0.34 and the *AC* value is 29.3.

Comparing the three barns, the insulated barn is more suited to cold weather in that it is more sensitive to the thermostat setting, less sensitive to changes in outside temperature, and condensation will occur at a lower outside temperature.

Barn E is more sensitive to thermostatic setting in that, if the outside temperature is 0 F and the inside thermostat setting is decreased from 50 to 40 F, the relative humidity inside will increase 10 percent in the insulated barn and only

6.5 percent in the fairly well-insulated barn and 0 percent in the poorly-insulated barn.

That the well-insulated barn is less sensitive to changes in outside temperature may be shown by decreasing the outside temperature from 10 to 0 F. The relative humidity will increase 12 percent in the fairly well-insulated barn and only 6½ percent in the insulated barn when the thermostatic setting is 50 F. Condensation will occur at a lower outside temperature for the insulated barn. In the case of the 50 F thermostatic setting, condensation would occur at an outside temperature of —15.5 F in the insulated barn and at 5 F in the fairly well-insulated barn.

Humidistat Control of Forced Ventilation

Barns E and C were again analyzed using a humidistat in place of the thermostat to control the fan. The graphic results showing inside temperature *(t_i)*, inside relative humidity *(RH_i)* and volume of air discharged by the fan *(V)*, are given in Fig. 14 and Fig. 15. The humidistat control point was set at 80 percent *RH* and 70 percent and the maximum fan ventilation capacity was again 6000 cfh per cow.

Barn E_H (Fig. 14). In this well-insulated barn the control point, 80 percent RH_i, is reached when the outside temperature falls to 9 F and the inside temperature is then 31 F. As the outside temperature continues to decrease, the ventilation rate decreases and the inside temperature again increases. When the outside temperature falls to —20 F, the inside temperature has risen to 62½ F, and the ventilation rate is 960 cfh per cow. The objection to this system of control is that the inside temperature reaches a minimum value at moderate outside temperatures, and as a result fluctuates over a great range as the outside temperature changes.

Barn C_H (Fig. 15). The humidistat control system for this barn, which has no insulation fill between the walls and does not have storm windows, is not feasible because the temperature differential between inside and outside air is not great enough to allow the ventilation system to discharge the required amount of air to keep the relative humidity below 80 percent. This system fails to balance properly when the outside temperature is lower than 1 F.

Combination Thermostat and Humidistat Control System

The peculiar fluctuation of the inside temperature caused by humidistat control of the well-insulated barn (barn E_H) may be overcome by a combination thermostat and humidistat control system (Fig. 16). The humidistat is used to control the ventilation system when the inside relative humidity reaches 80 percent. This system is shown in Fig. 16. Barn E_{TH} can be thought of as a thermostatic control system with a high limit control for humidity. When the humidistat is controlling in Fig. 16, the lines are dashed, and above 28 F there is no control of the ventilation system as it is running at maximum capacity.

There is no advantage to controlling barn C with a combination control system as the humidistat cannot be satisfied by the ventilation system below 1 F.

CONCLUSIONS

1 Humidistat control of a forced ventilation system for the average barn (double wall without insulation fill or less) is not advantageous because the control range is too narrow to be of value, and in this control range the inside temperature fluctuates too drastically with changes in outside temperature.

The animal, probably, and the operator, certainly, would be uncomfortable trying to regulate their temperature control mechanism to that of the uncontrolled barn.

The humidistat is best used as a high limit control of relative humidity in conjunction with thermostatic control, if the barn has the insulation properties of a double wall with insulation fill. The humidistat allows one to go to a lower outside temperature without condensation, and the thermostat takes out the objectional dip in inside temperature. The inside temperature will rise abruptly when the humidistat takes over at the low outside temperature, and the volume of air discharged by the ventilation system will rapidly reach the normal infiltration rate of the structure.

2 Thermostatic control is the more satisfactory type of control although it is greatly affected by the insulation properties of the structure.

3 For barns with double-wall construction, the thermostat should be set high (60 to 70 F) to prevent condensation on the walls. For barns with single-wall construction the thermostat should be set as low as possible (40 to 50 F).

4 Single-wall barns are generally good down to an outside temperature of about 10 F, and double-wall construction allows one to go down to —5 F or —10 F before condensation on the sidewall starts. Double wall with insulation fill will enable one to prevent condensation with outside temperatures as low as —20 F, if the inside thermostatic setting is 60 F or higher.

5 The sizing of a fan for a given barn is a function of the outside design temperature and the insulation properties of the barn.

If the outside design temperature is below 0 F, a 4,000 to 6,000 cfh per cow fan system would be adequate, and as the outside design temperature increases the capacity of the fan system may be increased to a maximum of 10,000 or 12,000 cfh per cow.

If the insulation properties of the barn are poor *(AC* above 28), the fan capacity should be at least 6,000 cfh per cow or a little better, because in these cases it is better to maintain a cold barn (low thermostatic setting) by moving a large amount of air to prevent condensation. As the insulation properties of the barn improve, the capacity of the fan may be diminished to 4,000 cfh per cow, which is the minimum ventilation rate recommended for good circulation.

APPENDIX

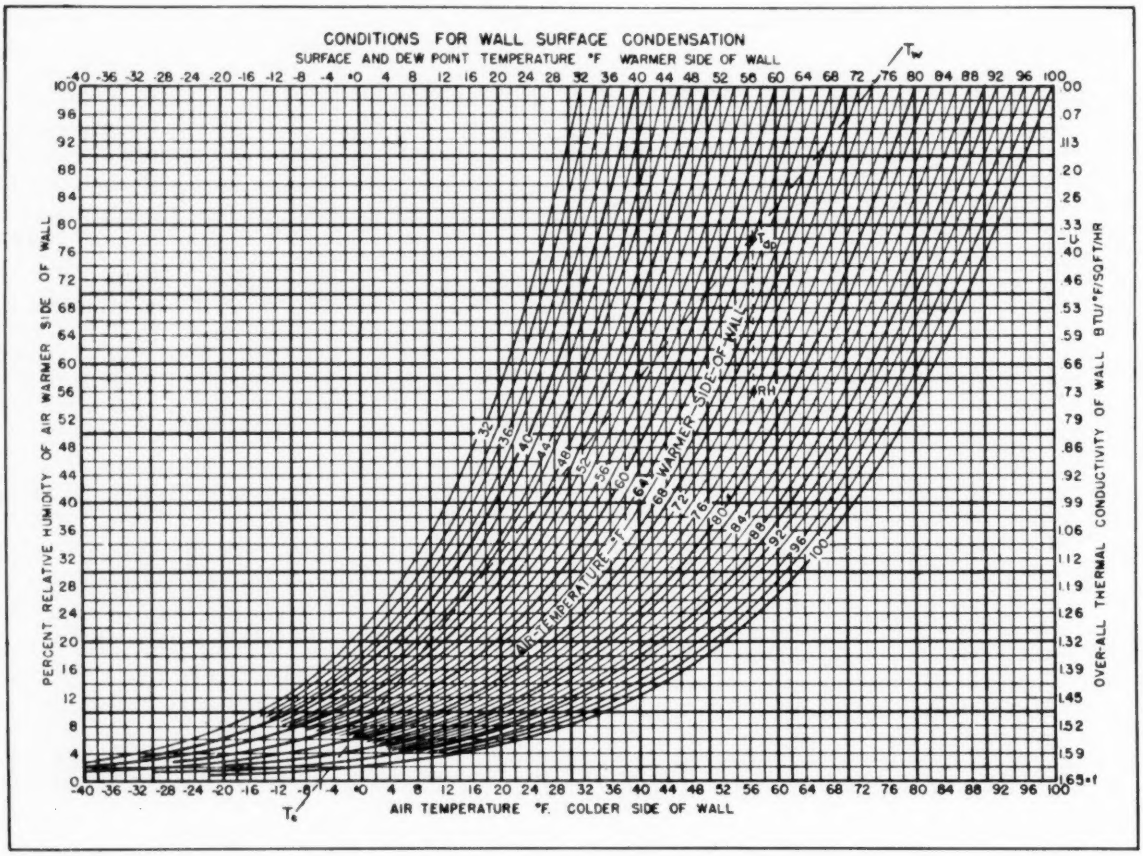
Diagram for Determining Wall-Surface Condensation‖

Conditions for wall-surface condensation—also for condensation on ceilings or floors—can be quickly determined by means of the accompanying diagram (see next page) when any three of the following four factors are known:

T_c = air temperature on colder side of wall

T_w = air temperature on warmer side of wall

‖Edgar, Alfred D.: A diagram for determining wall-surface condensation. AGRICULTURAL ENGINEERING, vol. 30, p. 336, July, '49.



U = over-all thermal conductivity of wall between T_c and T_w

RH = relative humidity of air on warmer side of wall.

For condensation, the warmer side wall surface is at or below the dew-point temperature, T_{dp}, of the air on the warmer side of the wall (1).

Lines of air temperature, T_w, for the warmer side of the wall run through intersections of lines for corresponding dew-point temperatures, T_{dp} and relative humidity, RH at 30 in of mercury (2).

Over-all thermal conductivity, U, includes internal conductance and that of both surfaces or films, of which the warmer side, still air-surface conductance, $f = 1.65$ Btu** (3).

Surface and dew-point temperatures, T_{dp}, are located at the intersections of the horizontal thermal conductivity lines, U, and a straight edge between air temperatures, T_c, on the colder side at the bottom and air temperatures, T_w, on warmer side, at top** (4).

EXAMPLE

To Find: Relative humidity, RH, for condensation on warmer side surface (1) when

Air temperature on colder side, at bottom, $T_c = 6$ F

Air temperature on warmer side, saturation line, at top, $T_w = 74$ F

Over-all thermal conductivity, $U = 0.36$ Btu.

Solution: Intersection of horizontal, $U = 0.36$ line and diagonal straight edge between $T_c = 6$ F and $T_w = 74$ F (bottom to top) locates $T_{dp} = 57$ F (3) (4).

Intersection of vertical dew point, $T_{dp} = 57$ F, and curved air temperature, on warmer side, $T_w = 74$ F line, at RH locates horizontal relative humidity, $RH = 56$ percent line (2).

**Values of U = percent (downward from top to bottom) × f, or percent = U/f. To locate T_{dp} corresponding to U, the percent (right to left, T_w to T_c) locates T_{dp} where $U/f = (T_w - T_{dp})/(T_w - T_c)$.

Free Research vs. Design Research

THERE is a choice between free and design research, or between supporting the man or the experimental design. Let us support the man.

Let us try to help improve the conditions of research for the individual worker. This means longer grants, fewer reports, less paper work.

Let us not ask men for detailed reports until they have completed their jobs. Half-finished reports only clutter up other men's minds and create confusion in the literature.

Let us try to give the funds for research with as few strings attached as possible, without asking a man exactly what he is going to do and why.

Let us not mistake experimental design for ideas.

Let us be careful how we handle a researcher's ideas. They belong to him. When he puts them on application forms, let us not broadcast them, scatter them far and wide to scrupulous and unscrupulous hands. Public agencies do this now with the result that authorship of ideas is often forgotten or ignored. The researcher's satisfaction comes from finishing a job – his own. He is human. It may have taken him years to work out his ideas. In wartime, yes, all ideas must be pooled and as quickly as possible. But not in peacetime.

Let us try to educate public agencies and legislators to see the importance of backing individuals—of betting on them—giving them greater freedom.—Curt P. Richter, in *Science*, July 24, 1953.

The Place of LP Gas as a Tractor Fuel

Lloyd H. Lamouria
ASSOC. MEMBER ASAE

OUT of a total of 75,000 wheel tractors and 40,000 track-type tractors in California, it is estimated that about 5 percent are operating on LP-gas. However, since about one-half of all California farms are using LP-gas for domestic purposes, this indicates a good possibility of expanded use of this fuel for power purposes.

The liquified petroleum gases used in agriculture have been propane and butane. Today butane has more valuable uses in the synthetic industry, and consequently only propane will be considered as a tractor fuel. Most of the present tractor conversions are on gasoline wheel tractors and therefore only the wheel tractor is considered in the cost analysis presented in this paper.

OTHER FACTORS BESIDES LP-GAS CARBURETION

In the spring of 1952, the average cost of converting a Farmall M tractor was $300 for a liquid withdrawal conversion or $230 for vapor withdrawal with the same propane tank and including carburetor, or $115 for vapor withdrawal using borrowed domestic cylinders and spud-in carburetion. These prices include labor and all the recommended changes but not the price of the bulk storage.

The compression ratio on a converted tractor is normally raised about one ratio, i. e., 5.5:1 to 6.5:1. This is possible due to the fact that propane has an octane rating over 100. Therefore, even at the higher compression ratio, there is no engine knock and a higher thermal efficiency is realized. By this means the lower heating value of propane per gallon as compared to gasoline can be partially or wholly offset. The extent of this benefit depends greatly upon how much the compression ratio is changed. Although factory-equipped tractors are now manufactured up to an 8:1 compression ratio, the ordinary gasoline engine and final drive could not withstand the increased power output resulting from increasing the compression ratio to 8:1 (Fig. 1). Also, due to the increased compression pressure, the ignition system and starter motor may be required to operate with a minimum margin of safety.

If the compression ratio is not changed, one can expect the fuel consumption to increase about 15 to 20 percent on a gallon basis. Comparative gasoline and LP-gas fuel consumptions at various loads and at existing production gasoline and LP-gas compression ratios are shown in Fig. 2. The latest Minneapolis-Moline tractor with an 8:1 compression ratio had not been tested at Nebraska at the time of this writing; therefore, it was not included in this analysis.

Whereas the compression ratio is the governing factor in determining relative fuel economy, the intake manifold principally controls the maximum horsepower output of the engine. If the intake manifold is not changed, one can expect a 10 percent loss in power (Fig. 1). This power loss is due to the lower volumetric efficiency of the propane engine when operating with the hot gasoline manifold. With gasoline, heat is added to the intake manifold to aid in the proper vaporization of the liquid gasoline. However, when using propane, the fuel is introduced as a gas which reduces the quantity of air which can be drawn into the cylinders at any given temperature. In order to overcome this restriction due to temperature, either a cold manifold is installed or the "hot spot" in the gasoline manifold is blocked off.

Cost of Use with Gasoline, LP-gas and Diesel Fuels. The following cost-of-use analysis is based on a 40 maximum drawbar horsepower wheel tractor and at typical California costs. Computations include all costs with the exception of operator labor and greases. Fuel consumption figures for the gasoline and propane tractors were taken as the average of Nebraska belt test E, tests 319 and 411 for the gasoline and propane tractors. Since this one manufacturer does not also have a diesel tractor of this same model already tested at Nebraska, a typical fuel consumption was chosen from Nebraska's belt test E for diesel tractors in this horsepower class. Average horsepower developed is thereby assumed to be 50 to 60 percent of maximum. Repair costs

This is an abridgment of a paper presented at the 21st annual farm machinery conference at the University of California at Davis, February, 1952.

The author — LLOYD H. LAMOURIA — is instructor in power, department of agricultural engineering, and junior agricultural engineer in the agricultural experiment station, University of California, Davis.

Acknowledgments: The author is indebted to Roger Yoerger, department of agricultural engineering, Iowa State College, to tractor manufacturers and dealers, to the California Liquid Gas Dealers Association, and to friends for their assistance in assembling the facts in the cost analysis presented in this paper.

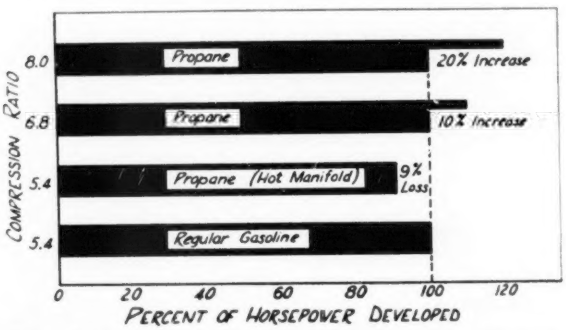


Fig. 1 Relation of compression ratio and intake manifold to power output. (Data by courtesy of Roger Yoerger, Iowa State College)

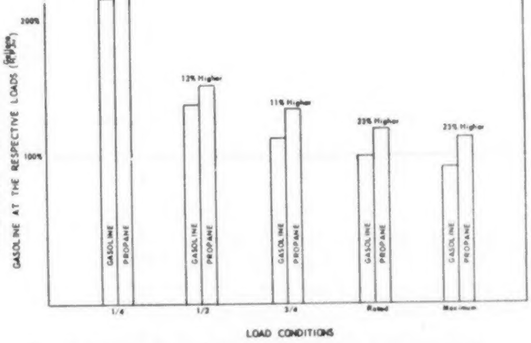


Fig. 2 Comparative fuel consumption at various loads (propane vs. gasoline)

are for comparative purposes and are based on the experience and repair records of one of the largest tractor service agencies in California. The repair cost estimates were also checked by the representatives of three tractor manufacturers.

This analysis will directly apply to either new or adequately converted tractors in this same $3000 price class. *NOTE*: For any specific farm or ranch this analysis should be recalculated, due to such variables as first cost, number of tractors or engines, type and volume of fuel storage, and local fuel-price differentials. Once the facts are available it takes only a few minutes to make a decision on (whether to use gasoline, propane or diesel as the engine fuel).

Depreciation on the tractors and storage equipment was computed by the straight line method which is taken as annually being the purchase price less the trade-in value divided by the service life. Trade-in value is assumed to be 10 percent of the purchase price. Service life on the tractors is taken as being 12 years and on the bulk fuel storages as 20 years.

$$\text{Depreciation per year} = (C-S)/SL$$

where C = purchase price
S = trade-in value
SL = service life in years.

Interest on Investment is taken as annually being 5 percent of the average investment. The average investment is the purchase price plus the trade-in value divided by two.

$$\text{Interest per year} = (C+S)/2 \times 5 \text{ percent.}$$

Insurance is taken as annually being 1.25 percent of the purchase price.

Taxes are taken as annually being 1.25 percent of the purchase price.

Housing is taken as annually being 1.0 percent of the purchase price.

Maintenance is taken on an annual basis as follows:

Gasoline wheel tractor 4.0 percent of purchase price.
Propane wheel tractor 3.0 percent of purchase price.
Diesel wheel tractor 5.5 percent of purchase price.
Gasoline and diesel storage 5.0 percent of purchase price.
Propane bulk storage 4.0 percent of purchase price.

Fuel Consumption

Gasoline 100 percent on a gallon basis
Propane 112 percent of gasoline on a gallon basis
Diesel 68 percent of gasoline on a gallon basis

Fuel Price per Gallon

Gasoline 18c in 500-gal lots
Propane 12c in 500-gal lots
Diesel 12c in 500-gal lots

Oil and Filter Life

Gasoline 100 percent
Propane 300 percent of gasoline filter life
Diesel 60 percent of gasoline filter life

Oil Price per Gallon

All engines 70c in barrel lots

RESULTS

By taking into account all the cost variables, with the exception of difference in refueling time and grease for chassis lubrication, Fig. 3 is plotted. Showing the cost of use per year, Fig. 3 is helpful when considering the relative savings of one fuel as compared to another. If the choice lies only between a gasoline and an LP-gas tractor, the graph shows that the cost of use of the LP-gas tractor is less per year, after the annual use exceeds about 400 hr per year. This conclusion should apply principally to those who wish to convert an existing gasoline tractor.

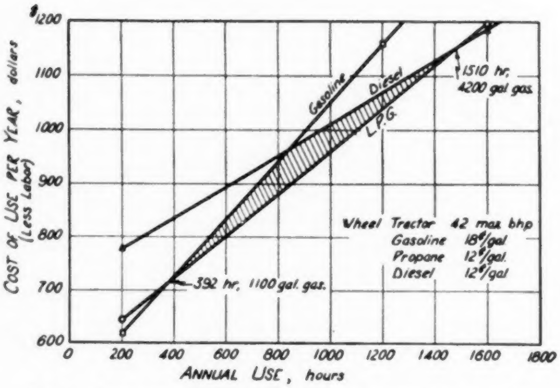


Fig. 3 Comparative cost of annual use of tractor operating on gasoline, diesel and propane fuels

For those owners who are considering buying a new tractor, the diesel as well as the gasoline and LP-gas engine should be considered. *On this basis the gasoline tractor is most economical under 400 hr of annual use, the LP-gas tractor is most economical in the range from 400 to 1500 hr annual use, and the diesel tractor has the lowest cost of use above 1500 hr per year.*

Since the graph represents only those tangible differences which can be calculated for the typical case, the following summary is presented:

ADVANTAGES OF LP GAS FUEL

1 About 25 percent less maintenance cost than gasoline tractor
2 About 50 percent less maintenance cost than diesel tractor
3 About 25 percent less fuel and oil cost than gasoline tractor
*4 No objectionable exhaust odors
*5 Engine performs smoothly even when cold
*6 Minimum storage losses due to evaporation, spillage and pilferage.

DISADVANTAGES OF LP GAS FUEL

1 About 35 percent higher fuel and oil cost than diesel tractor
2 Special fuel storage
*3 Emergency refueling difficulties
*4 Conversion may hamper visibility or mounting implements
*5 Conversion may overload front tires and result in short tire life and hard steering
*6 Instability of price structure
*7 Local garage servicing of LP gas equipment.

*Factors not included in graphic analysis.

Fuel consumption on the new LP-gas factory-equipped tractors will show a higher fuel economy than indicated by this paper. Also, if LP-gas is used for domestic purposes as well as power, part of the storage-tank amortization will be carried by the home. Besides this factor, the fuel will be about one cent per gallon cheaper due to the larger deliveries.

CAUTION: This paper exemplifies a method of calculation common to all farms, but *the results are valid only for the special case considered.* Only cost data that specifically pertains to the operation in question should be used.

LP-gas as a tractor fuel must be considered on the basis of all its merits, both good and poor. Agricultural engineers are interested in a minimum unit cost of production. On the basis of the factors discussed in this paper, the fuel most nearly fulfilling the individual's needs is the fuel which he should be using.

Packaged Electronic Ventilation Control

B. C. Haynes and C. V. Longo
ASSOC. MEMBER ASAE

DURING the fall of 1950, difficulty was encountered in maintaining optimum potato storage temperature in thermostatically controlled, force-ventilated potato storages in the New Jersey area. Although outside temperature was sufficiently low to maintain 40F storage temperatures, and intake duct minimum thermostats were set for 30F, storage temperatures remained above 42F.

Analysis of duct minimum thermostat lag indicated that this control was the chief cause of the difficulty encountered.

At the same time, attention was brought to focus on industrial differential thermostats which provided the primary type of control used for storage ventilation systems. The majority of these controls will operate on a temperature difference of no less than 4F. This is an optimum figure. Frequently, because of the need to place sensing elements, etc., to conform to storage structures, it is impossible to maintain operation with less than a 7F differential.

Since this is an area having a comparatively mild winter climate, it was considered desirable to obtain a differential thermostat which would function within a smaller temperature differential. With this thought in mind, Potter*, Longo and Claycomb† commenced design and fabrication of an electronic differential thermostat in the fall of 1950. A pilot model was available for laboratory testing by early January, 1951.

The electrical design of this pilot model, as suggested by Potter and detailed by Longo, is shown in Fig. 1. A description of its operation follows:

There are three principal elements of the circuit namely, (1) a biased polarized relay (relay No. 1), (2) an electronic amplifier tube (6J6), and (3) a Wheatstone bridge with thermistors in two of the bridge arms.

The action of the relay is controlled by the flow of electric current in the two coils of the polarized relay. When the current in one of the coils exceeds the current in the second coil by a predetermined amount, the relay contacts will close, and actuate the power relay (relay No. 2). On the other hand, if the current in the first coil does not exceed the current in the second coil by the required amount, or if the current in the second coil actually exceeds that in the first coil, the relay contacts will remain in the open position, or they will revert to that position when the critical differential value of current is reached, if previous conditions of current had been such as to cause them to close. Thus the polarized relay is actuated according to the differential current in the coil.

The control coils of the polarized relay are connected in the plate circuits of the 6J6 amplifier tube, and thus the flow of current in the coils is under control of the voltages applied to the grids of the 6J6 tube. These control voltages are derived from the error voltage appearing at the output terminals of the Wheatstone bridge. This error voltage results when a difference in temperature between the two thermistors causes their electrical resistance to differ sufficiently to cause electrical unbalance in the bridge. If the thermistors are properly matched, they will have equal resistance when the temperature is the same in each. Therefore, difference in temperature is the only factor that will unbalance the bridge and thus, through the action of the amplifier tube, cause sufficient difference in the currents flowing in the control coils of the relay to actuate them. Moreover, since the action of the relay is polarized and will respond to an excess current in one of the coils but not in the other, this action will be initiated by an excess temperature in one of the sensitive elements but not in the other.

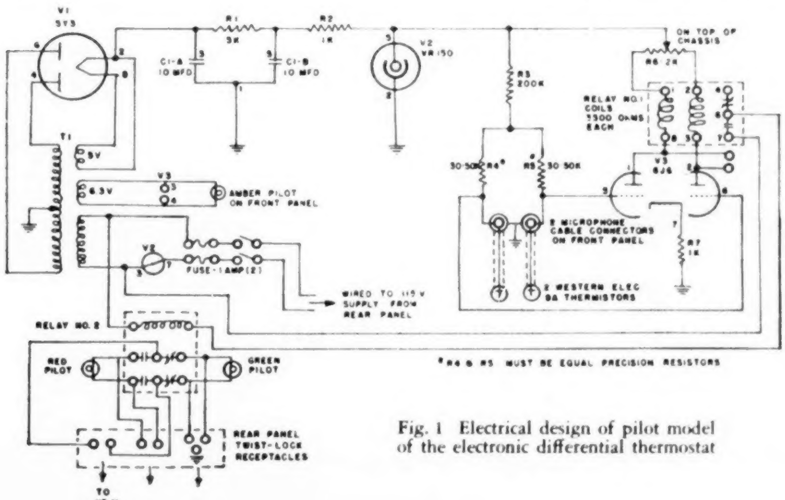


Fig. 1 Electrical design of pilot model of the electronic differential thermostat

The pilot model previously described was further tested under actual storage conditions during the winter of 1951-52. During these storage tests the control consistently maintained a differential of 2F even when power source voltages fluctuated between 102 and 124 v.

The pilot model was modified by the addition of a second sensing circuit (consisting of a similar Wheatstone bridge, 6J6 amplifier tube, and polarized relay) during the spring of 1952. The Wheatstone bridge of this second sensing circuit utilizes a thermistor in one arm, a variable resistance in the second arm, and fixed resistors in the remaining two arms. This second sensing circuit furnishes minimum

(Continued on page 830)

This paper was prepared expressly for AGRICULTURAL ENGINEERING.

The authors — B. C. HAYNES and C. V. LONGO — are, respectively, associate agricultural engineer, division of farm buildings and rural housing (BPISAE), U.S. Department of Agriculture, and assistant professor of electrical engineering, Rutgers University.

*Potter, James L., professor and chairman, department of electrical engineering, Rutgers University.

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Prevention of Fatigue Failures in Farm Machine Parts

William E. Gustin

THE principles involved in the prevention of fatigue failures are most readily explained by referring to the conventional S-N curve in Fig. 1. The S-N curve is the threshold of the combination of reversed stress and number of cycles above which fatigue failures will be experienced.

The S-N curve plotted on semilog or log log paper has a knee or break at approximately one million cycles indicating the endurance-limit stress. At stresses slightly below the endurance limit, a part can operate several million cycles before failure occurs. The number of times a stress is applied in a part is to a considerable extent fixed by the function of the part; that is, parts such as crankshafts, connecting rods, gears, axles, etc., definitely operate more than a million cycles, and therefore the operating stress must be below the endurance limit if failure is to be avoided. Parts, however, like frames, hand-operated levers, hydraulic cylinders, etc., operate for a smaller number of cycles and may successfully operate above the endurance-limit stress.

This paper was presented at the winter meeting of the American Society of Agricultural Engineers at Chicago, Ill., December, 1952, as a contribution of the Power and Machinery Division.

The author—WILLIAM E. GUSTIN—is a project engineer in the applied mechanics section, engineering department, John Deere Waterloo Tractor Works of Deere Mfg. Co.

Knowing approximately the number of cycles a part is expected to operate, the information required to prevent fatigue failures is:

1 The actual operating stress in the part
2 The S-N curve of the part.

In any case the general problem is to provide fatigue strength in excess of the operating conditions.

Fatigue cracks usually start at the surface of a part, in a notch, sharp change in section, keyway, screw thread, oil hole, tool mark, etc. The notch brings the local stress up, sometimes above the endurance limit, even though the nominal calculated stress is well below the yield point or even below the endurance limit of the material. The actual stress in a part can, therefore, be determined most accurately by strain measurements under operating conditions.

The fatigue strengths of most materials are fairly well known; however, it is our experience that the size and shape of the part and the effect of heat-treatment provide considerable variation in fatigue life of different parts of the same material. The practical solution, therefore, is to run laboratory fatigue tests on actual parts rather than on test bars.

In some special cases where service fatigue failures are

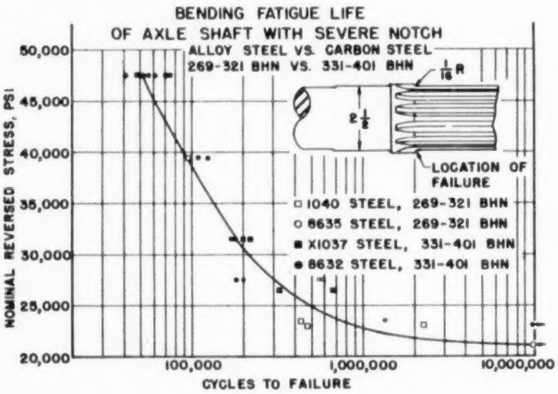


Fig. 1

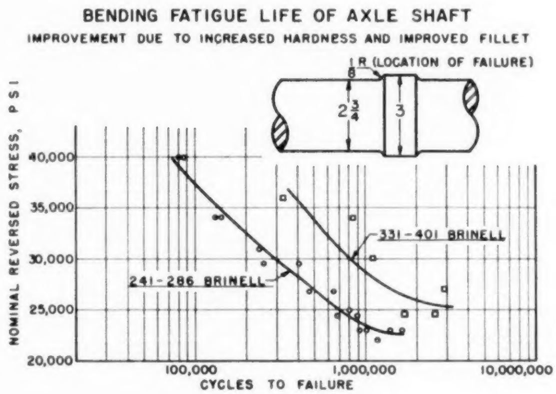


Fig. 2

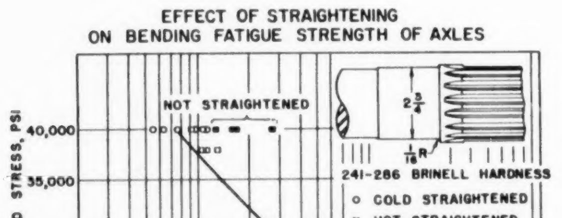


Fig. 3

Fig. 4

experienced, a correlation between laboratory test conditions and field operating conditions may be obtained which eliminates the need to measure actual operating stresses. For example, service failures on axles which were overloaded by use of axle extensions and heavy mounted implements indicate that the average field operating stress is approximately 1.3 times greater than on the rotating bending fatigue test machine in the laboratory which is based on static loads.

This paper is primarily concerned with evaluating the methods we have used for reducing the critical stress or increasing the fatigue strength of particular parts without increasing the size of the part. Reasons for increasing fatigue strength without increasing the size of the part are:

1 Many times a design is frozen before the need for additional fatigue strength is apparent, and considerable additional cost would be involved in changing associated parts if the size of the critical part is increased.

2 A piece of equipment, no matter how well designed and tested, may be placed in service under conditions for which it was not intended. In such cases it is advantageous to provide a replacement part with increased fatigue strength and still be interchangeable with the original part.

Fig. 1 compares the fatigue strength of axle shafts of two different materials and at two different hardness levels. This is a 2½-in diameter shaft with a 1/16-in radius on a 2⅝-in diameter shoulder where the splines run out. All four sets of test data fall within the same scatter band so that the following conclusions may be made:

1 Alloy steel at the same hardness level provides no improvement in fatigue life over carbon steel in this design.

2 Increasing hardness, when a severe notch is involved, provides no improvement in fatigue strength. (Torsional yield point is increased from 120,000 in-lb to 190,000 in-lb, or 58 per cent by this increase in hardness.)

Fig. 2 compares the fatigue strength of axles, which have a ⅛-in ground radius on a 3-in diameter shoulder at two hardness levels. Here an average improvement of 11 per cent in endurance-limit stress is obtained by an increase in hardness from 241-286 to 331-401 Brinell.

Limited fatigue tests on axles that had not been straightened indicated an average improvement from 80,000 to 175,000 cycles at one stress level, as shown on Fig. 3. Since the axles had to be straight, fatigue tests were conducted on axles that had been straightened while hot (800 F out of the temper furnace). Tests were also run on axles that had been held straight in rolls during the quench. These test results indicate no appreciable difference in fatigue life of hot-straightened and cold-straightened axles.

In some cases additional notches can be cut in the vicinity of a critical fillet so that the maximum stress is reduced. For example, Fig. 4 illustrates cutting two additional notches next to a crankpin fillet. These additional notches reduced the critical stress 18 per cent and provided a 10 per cent improvement in endurance-limit stress.

Another case of similar improvement was obtained by shot peening the critical fillets of the crankshaft. Fig. 5 shows that 12 per cent improvement in endurance limit is obtained by shot peening. Since these two curves tend to

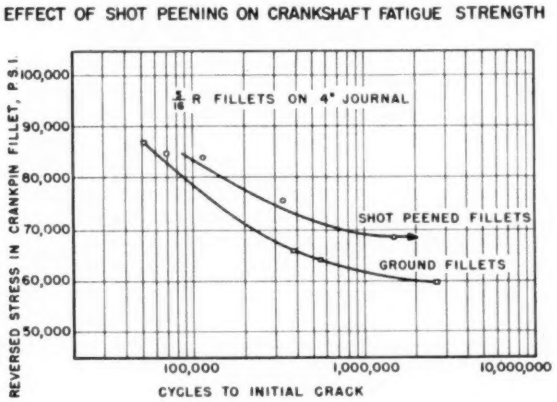


Fig. 5

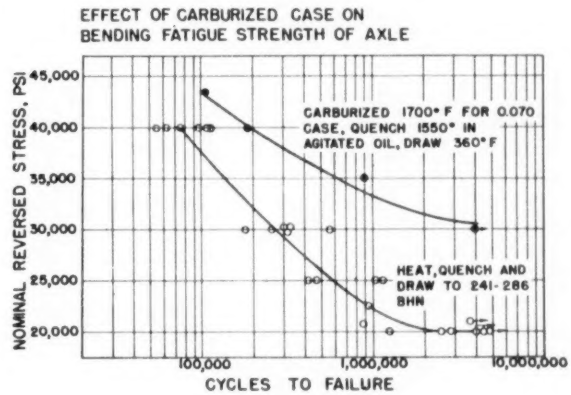


Fig. 6

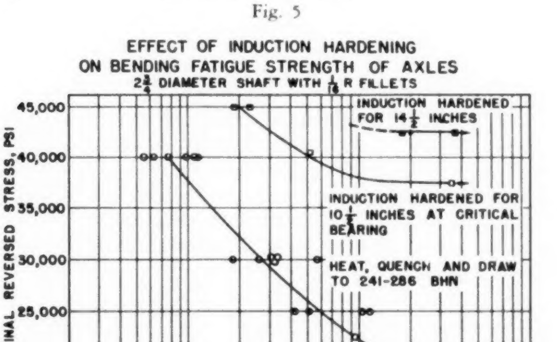


Fig. 7

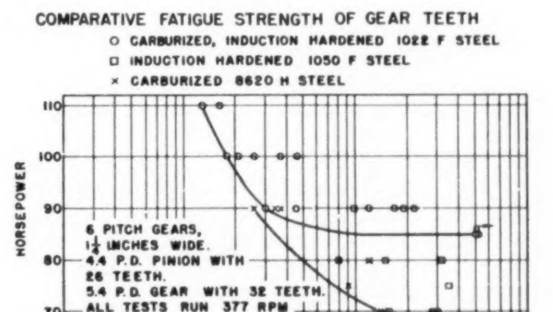


Fig. 8

converge at the higher stress, it is obvious that shot-peening is of less value if a part is operating in the finite portion of the S-N curve.

Fig. 6 shows the effect of a carburized case on the bending fatigue strength of an axle. Admittedly this method is not a very practical application here; however, an improvement of 50 per cent in endurance-limit stress warrants its consideration in some problems.

One of the most surprising improvements we have obtained to date in the elimination of bending-fatigue failures is by induction hardening. As shown in Fig. 7, induction hardening a 10½-in length in the critical bearing area raised the endurance limit stress from 20,000 to 37,500 psi. Since this moved the point of failure from the bearing shoulder to the end of the induction-hardened area, the length of the induction hardening was increased from 10½ to 14½ in, raising the endurance limit to 42,500 psi, or more than 100 per cent improvement over the regular heat-treatment. It is believed that induction hardening provides a compressive residual stress which partly nullifies the effects of sharp notches, since the improvement obtained is more than can be expected from the increase in hardness. The same percentage improvement has been obtained by induction hardening different sizes of axles varying from 2½ to 3 3/16-in diameter.

EXCEPTIONAL RESULTS BY INDUCTION HARDENING

Some rather exceptional results have also been obtained by induction hardening gears after they have been carburized and air-cooled. Fig. 8 shows the results of laboratory gear test machine results comparing 1022 F steel carburized, air-cooled and induction hardened, with 1050 F steel induction hardened only and with 8620 H steel carburized and direct quenched. The endurance limit of the carburized, induction-hardened gears has been better than carburizing or induction hardening in every case we have tested to date.

While not evident from the S-N curve, the carburized, induction-hardened gears had no pitting after 5 million cycles at 85 hp, whereas the plain induction-hardened gears were badly pitted after 3 million cycles at 70 hp.

Summarizing the results of the various fatigue tests, the following conclusions are made:

1 No measurable improvement in fatigue strength is obtained by substituting alloy steel for carbon steel as long as the same hardness is maintained.

2 Where sharp notches are involved, no appreciable improvement in fatigue strength can be obtained by increased hardness.

3 Hot straightening provides no appreciable improvement over cold straightening.

4 Increasing hardness from 241-286 to 331-401 Brinell improves endurance limit 11 per cent where an improved fillet replaces the severe notch.

5 Additional grooves can be cut in the vicinity of a severe notch to reduce maximum stress and to increase the endurance limit 10 per cent.

6 Shot-peening increases the endurance limit 12 per cent but does not provide as much improvement in fatigue life at stresses above the endurance limit.

7 Carburizing, where applicable, can improve endurance limit in bending by 50 per cent.

8 Induction hardening improves endurance limit by as much as 100 per cent over regular heat, quench and temper.

9 Carburized, induction-hardened gears have provided higher endurance limit and better resistance to pitting than plain induction hardening or carburizing and direct quench.

The percentages of improvement in fatigue life shown in these conclusions apply only to the particular parts tested, however, these results can profitably be used as a guide in the prevention of fatigue failures of similar parts.

Electronic Ventilation Control

(Continued from page 827)

temperature control in the air duct and is set by the variable resistor. The two polarized relays are connected to the power relay in series.

The three thermistors which serve as the temperature sensing elements for the differential and minimum thermostat circuits are encased in ½-in diameter molded plastic rods. The plastic rods are integrally molded to co-axial cable connectors, and the thermistor leads are soldered to these connectors. This arrangement provides for easy replacement of thermistors, thermal damping of the thermistor response sensitivity, and protection of the thermistor from moisture which would affect its acuracy.

The Western Electric 9A thermistors used were chosen for their high "cold resistance" (31,500 ohms at 25 C) and their high temperature coefficient of resistance (-4.4 percent per degree C at 25 C). The high temperature coefficient provides high circuit sensitivity. The high cold resistance minimizes the effect of resistance in the connecting wires.

The modified control unit furnishes all controls necessary for storage ventilation in one "package". Some of the outstanding features of such packaged ventilation control are:

1 Freedom from restriction in locating the sensing elements. The differential thermostat sensing elements need not be placed at the same level as is necessary with industrial vapor-filled differential thermostats.

2 Remote location of control circuit. Up to several hundred feet of connecting wire might be used to connect the sensing elements (thermistors) to the control panel. This arrangement not only makes servicing easier but allows placement of the control panel (with indicating pilot lights) in an area where intermittent observation of the control system is convenient.

3 High accuracy and sensitivity.

4 Elimination of special wiring for a control circuit. All connections might be of the plug-in type.

5 Adaptability. By choosing two thermistors which have the same temperature coefficient of resistance, but slightly different total cold resistance, it is possible to procure a differential which will vary with the ambient temperature. With such an arrangement it would be necessary to insert a resistor, in the one bridge arm, in series with the thermistor which had the least total cold resistance. The value of the resistor would have to be of an order which would equalize the total resistances of the two thermistor arms of the bridge at the ambient temperature where a minimum differential was desired. Such an arrangement might be used to provide for ventilation of a storage with outside air at 40F, if the storage were at 42F, and yet prohibit ventilation with outside air at 55F unless the storage temperature were 60F.

6 Safe "failing" characteristics. In the event of power failure, the control will always fail "safe".

The Soil Penetrometer in Soil Compaction Studies

C. W. Terry and H. M. Wilson
MEMBER ASAE

THERE are so many variables involved in determining land values that it is impossible to tell by means of any mechanical device, how profitable a given piece of land may be. But changing circumstances alter the situation from day to day, and it has been found that income-producing characteristics of soil may be related to physical characteristics that can be measured with rather simple tests and a device known as a soil penetrometer.

Such variables as geologic formation and geographic location must be treated separately and common sense with good judgment are necessary in the selection of good farm land.

Increasing population and the need for greater mechanization of farming operations require higher standards of efficiency. We must not be satisfied with low yields and farm products of inferior quality.

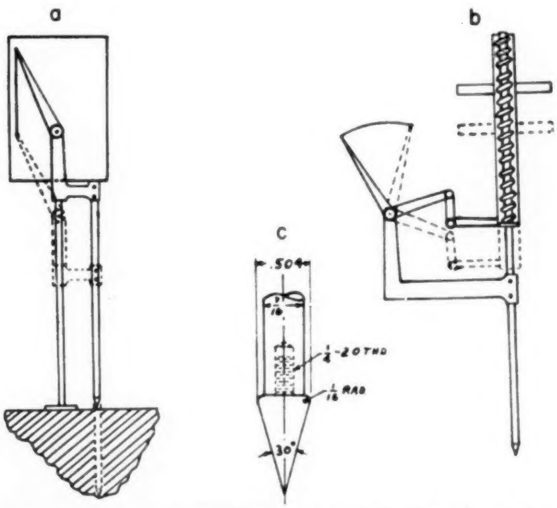
If then some relation can be found between natural phenomena and factors affecting yield and quality, it is important to determine and make use of that relation.

There is such a relation between soil compaction and its ability to absorb and retain moisture. There is also a relation between soil compaction and the force required to push a probe into it. Thus, in a round about way, we may determine how much of the rain which falls on a given area will run off and how much will be available to promote plant growth.

Readings of a soil penetrometer may be related to other soil characteristics, but the problem of soil productivity is so complex that a penetrometer would be of little use to one not well-versed in agronomy.

This paper was presented at a meeting of the North Atlantic Section of the American Society of Agricultural Engineers at Farmingdale, N. Y., September, 1953.

The authors — C. W. TERRY and H. M. WILSON — are, respectively, professor of agricultural engineering and extension soil conservationist, Cornell University.



Sketch of Cornell soil penetrometer. (a) Arrangement for plotting of the distance penetrated into the soil. (b) Arrangement for plotting the force required to secure the penetration. (c) Probe point

The Cornell soil penetrometer* was devised to help demonstrate the dangers arising from some more common farm tillage practices, and to permit rapid accumulation of data in the field. It was thought that the commonly used hammer-type instrument was too cumbersome and required too many man-hours for taking and interpreting data for any but exacting scientific studies. The Cornell penetrometer is compact, light and easy to operate. The later model uses an automobile valve spring to measure the force. For some of the work on Long Island during the summer of 1953 a model was constructed, the probe of which could penetrate about two feet of soil. This meant reducing the pencil travel to one-half the actual depth of penetration.

The Cornell penetrometer was first demonstrated at a county agent training school in December, 1952. Since that time it has been used in thirty-eight counties before audiences of from 100 to 500 people. Following each of these uses many requests were received from farmers who wanted their fields examined. Most of these requests have been given attention and the results have greatly increased our knowledge of the nature and extent of the soil-compaction problem in New York state.

At field events compaction is demonstrated by testing the penetrability of a soil before and after a tractor is run over it. Unfortunately most of the teaching by extension workers is done in the winter months when field work is impossible. Therefore, it was necessary to set up a demonstration that would simulate field conditions as closely as possible. An experiment conducted and reported by Free was selected for reproduction (Free, G. R. et al: "Compactibility of Certain Soils as Related to Organic Matter and Erosion"). In this study it was found that the volume density of a Honeoye soil was increased from 1.35 to 1.50 by running a tractor wheel over it. The degree of compaction was the same when the test was conducted under dry and wet soil conditions. However, while the permeability of the soil was reduced when it was packed under dry conditions, it was affected to a far greater extent when the tractor was run over the ground when it was wet. This is shown in the following table:

TIME REQUIRED FOR 1.4 IN OF WATER TO PENETRATE SOIL OF VARYING MOISTURE CONTENT

Volume weight of soil (water = 1.0)	Moisture content 18 percent	21 percent	24 percent
1.35	2 min	2 min	4 min
1.50	40 min	40 min	3960 min

In using the results of this experiment for a demonstration, soil is packed into a 6-in pipe to a volume density of 1.35 and probed with the Cornell penetrometer. (The method of calculating soil density is shown in the appendix to this paper.) With soil at this density only about 25 lb of weight is required to force the probe rod down to a depth of 13 in. A hydraulic *(Continued on page 834)*

*AGRICULTURAL ENGINEERING, vol. 33, p. 425—July, 1952.

Performance of Dairy Plant Receiving Rooms

Carl W. Hall
MEMBER ASAE

EQUIPMENT is often selected which is larger than necessary for the efficient operation of the receiving room of a dairy plant, and which requires additional investment, more building space, and more labor for cleaning than necessary. Also, other plants have equipment which is smaller than needed for the efficient operation of the receiving room, and requires more labor than is necessary. This paper describes methods which may be used to select the proper size of equipment for dairy and other milk-processing plants.

Nine dairy plant receiving rooms in southern Michigan were studied from the standpoint of the efficiency of labor and equipment. A time study was made of each operation in the receiving room and used for establishing standard times (Table 1).

The receiving room of a dairy plant contains a conveyor for carrying the milk in 10-gal cans into the plant, weigh can, receiving tank, can washer, and an outgoing empty-can conveyor. A clarifier and storage tank are often placed in the receiving room.

TABLE 1 STANDARD TIME FOR RECEIVING ROOM OPERATIONS

(Dumper checks for quality unless otherwise specified)

	Time, min
A For one-man operation:	
Dumping time per can	0.100
Weighing, recording weight, emptying weigh can	0.130
Sampling time	0.070
B For two-man operation:	
1 One man dumping, one man weighing and sampling—	
Dumping time per can	0.091
Time for weighing and sampling between producer lots	0.060
2 One man dumping and weighing, one man sampling—	
Dumping time per can	0.100
Time for weighing by dumper	0.130
C For three-man operation:	
1 One man dumping, one man weighing, one man sampling—	
Dumping time per can	0.091
Time for draining weigh can between producer lots	0.020 to 0.060
2 One man dumping, one man loosening lids and checking for quality, one man weighing and sampling—	
Dumping time per can	0.091
Time for weighing and sampling between producer lots	0.060

Conveyor. The length of conveyor in the different plants varied greatly. The length of the incoming conveyor varied from 20 to 45 ft, and the length of outgoing conveyor varied from 60 to 100 ft. An analysis was made to determine the optimum length of conveyor required (Fig. 1). It was based on receiving 100 10-gal cans from a truck load, with the trucker unloading cans and loosening lids at the rate of 7 cpm (cans per minute). Two minutes were allowed for moving the truck to the empty-can conveyor from the unloading position. A conveyor speed of 15 cpm was assumed. The time for emptying the cans for different incoming conveyor lengths of from 0 to 90 ft for different dumping rates was calculated and plotted. The total length of conveyor was obtained by adding the incoming conveyor length to the empty-can conveyor length necessary so that the dumping rate was not slowed down because of an accumulation of empty cans on the conveyor. The empty-can conveyor includes the length of the washer.

A very important relationship exists between the conveyor length and the time required for dumping when the dumping rate is above the 7 cpm rate at which the cans are placed on the conveyor by the man unloading the truck. For example, for a dumping rate of 10 cans per minute, the dumping time for 100 cans is reduced from 12 to 10 min as the conveyor length is increased from 30 to 60 ft (cans) on the incoming side. A total conveyor length of 138 ft is required for a 60-ft incoming conveyor and a total length of 130 ft for a 30-ft incoming conveyor. As the incoming conveyor length is increased from 60 to 90 ft, the total conveyor length is decreased to 126 ft.

Assuming that the dumper does not start to empty cans until the incoming line is full, this relationship is explained as follows. As the incoming conveyor is lengthened, the number of cans remaining in the truck for the trucker to unload is decreased. Thus the trucker can unload the cans, move the truck to the empty-can conveyor, and remove cans from the empty-can conveyor sooner than if a short incoming conveyor is used.

When both gravity and power conveyors are used, there is a tendency for the cans to lodge at the junction of the two conveyors. To prevent pinching of the cans while dumping, they should be dumped at right angles to the incoming conveyor.

Weigh Can. The milk is dumped from 10-gal cans into a large can in which the milk is weighed and sampled. These cans, called weigh cans, are normally manufactured in approximately 500-, 750-, and 1000-lb sizes. It would be desirable from the labor standpoint to have a weigh can

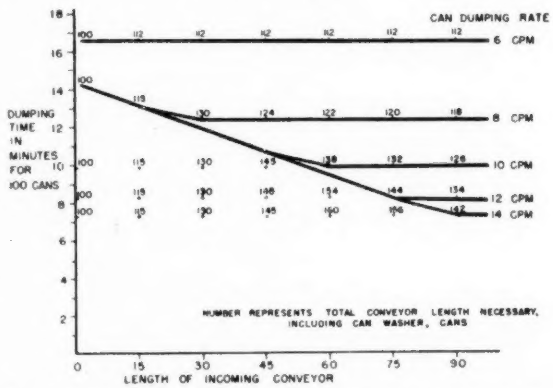


Fig. 1 Relationship of dumping time and conveyor length (in feet or cans) for different lengths of incoming conveyor and different dumping rates

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The author—CARL W. HALL—is associate professor of agricultural engineering, Michigan State College.

which holds all the milk of any one producer, so that it would be necessary to weigh and sample each producer's lot only once. However, the larger weigh cans cost more and may be uneconomical for a small plant or for a large plant with a small number of large producers.

For dairy plants as large as 80,000-lb per day capacity, the 750-lb weigh can will suffice in areas where there is an average of five or fewer cans per producer. Fig. 2 was developed to compare the costs for 500-lb and 750-lb weigh cans for different sizes of dairies. This chart relates the number of producers over 500-lb, the cost of replacing (including installation), the 500-lb with the 750-lb weigh can, to the years required to pay for the added cost by the labor saved. It applies to a one-, two-, or three-man receiving-room operation.

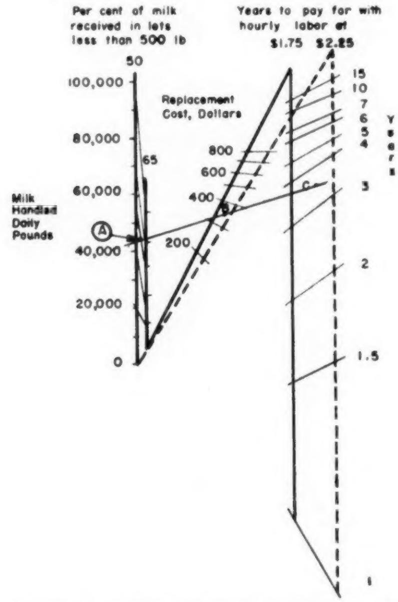

Fig. 2 Chart for determining years required to offset additional cost of 750-lb weigh can in comparison with a 500-lb weigh can by labor saved

The use of Fig. 2 in determining whether the existing 500-lb weigh can should be replaced with the 750-lb weigh can is illustrated by the following example. A dairy plant is receiving 60,000 lb of milk daily with 60 percent of the milk in less than 500-lb lots, as shown by A in Fig. 2. The replacement cost for the 750-lb weigh can is $350 (including cost of installation) with labor at $2 an hour, as shown by B. Along line AB extended, locate C at the appropriate hourly rate and read 3.6 years to pay for the 750-lb weigh can. Even though the normal life of the weigh can is 12 years, the dairy should plan to pay for the new equipment by the labor saving within six years, to avoid the possibility of loss through obsolescence. Therefore, replacement of a 500-lb weigh can would be justified. Fig. 2 can be used for the selection of a new weigh can.

Straight-Away Can Washer. The straight-away can washer is commonly used in dairy plants with capacities over 20,000 lb per day but is recommended for plants as small as 10,000 lb per day. The straight-away can washer is sold in sizes ranging from 6 to 14 cpm. A can washer should be selected which will permit the maximum rate of dumping which is shown in Table 2.

The one-man operation is much more efficient than multiple-man operations for receiving rooms. One man can easily handle 80,000 lb of milk per day with equipment which is properly selected and arranged. A multiple-man receiving room operation is justified to speed up the receiving operation in order to assure continuous processing.

TABLE 2 RATE OF DUMPING (CPM) FOR MANUAL WEIGHING AND EITHER VACUUM OR HAND SAMPLING

Workers in receiving room	Average number of cans dumped per minute for producer of 2.5 cans	5.0 cans	7.5 cans	10.0 cans
1	5.2	7.1	7.6	8.2
2	8.7	9.7	10.0	10.3
3	8.9	10.0	10.5	10.9

A can washer should be selected which has an operating capacity larger than the dumping rate of the worker as shown in Table 2. The sizes of can washer required to permit the can dumper to attain the maximum dumping rates are shown in Table 3.

TABLE 3 DUMPING RATE OBTAINABLE WITH DIFFERENT SIZES OF CAN WASHERS, IN CPM

(Manual dumping, five cans per producer)

Can washer size, cpm	One-man operation	Two-man operation	Three-man operation
6	5.5*	5.6	5.8
8	6.1	7.3	7.7
10	7.1	8.9	9.5
12	7.1	9.7	10.3
14	7.1	9.7	10.3

*The calculated value is 5.0 cpm. However, an operator was able to obtain 5.5 cpm by moving a can into the washer with an extra movement of his arm between the time of sampling and time of recording the weight.

From these data it is evident that the 10-cpm washer will suffice for a typical one-man receiving operation where five or less cans are received from a producer. One man can manually dump, weigh and record 7.1 cpm. A 10-cpm straight-away washer permits a dumping rate of 7.1 cpm for a five-can producer (Table 2).

TABLE 4 OVER-ALL LABOR EFFICIENCY OF RECEIVING ROOMS

(Manual weighing and recording)

Number of 100 cans	Actual performance, man-min for 100 cans	Cans per minute obtained	Size of can washer, cpm	Goal for 5 can producers, man-min for 100 cans	Worker's tasks*	Major causes for delays
1	17.9	5.6	10	14.1	A	(a)
1	16.6	6.0	12	14.1	A	(b)
1	21.8	4.6	8	14.1	A	(c)
1	18.2	5.5	6	14.1	A	(d)
2	30.4	6.6	7	20.6	B(1)	(e)
2	35.0	5.7	13	20.6	B(2)	(f)
3	34.2	8.8	14	30.0	C(2)	(g)
3	31.2	9.6	13	30.0	C(1)	(h)

(a) Low capacity clarifier, cans not supplied to dumper rapidly enough, can washer lid discharge not functioning properly.

(b) Can washer lid feed not functioning properly, cans pinched while dumping.

(c) Vacuum sampler used inefficiently.

(d) Small can washer.

(e) Cans supplied to dumper too slow, small can washer.

(f) Same person dumping and weighing; sampler should weigh.

(g) Cans supplied to dumper too slow for multiple-man receiving room, man loosening lids not fully occupied.

(h) Cans supplied to dumper too slow.

*See Table 1 for description of worker's tasks.

To reduce milk waste, a drip pan should be placed between the weigh can and washer to collect the milk which adheres to the can. For a 10-cpm washer, a draining space for four cans is recommended, so that a time for draining of 0.40 min is provided.

Rotary Can Washer. A rotary can washer that is built with capacities from 3 to 6 cpm is recommended for small plants. One man can conveniently handle 5.86 cpm into and out of the rotary can washer. It is usually necessary to carry the cans away from the washer, in which case a 3-cpm unit will usually suffice.

An analysis of economic factors in the use of the rotary and the straight-away can washers based on 1952 prices showed that the rotary can washer should be used in a dairy plant receiving room having a capacity less than 10,000 lb per day. Over the past 15 years the rotary washer has been recommended for a plant of 20,000 lb per day and less.

Over-all Efficiency of Receiving Room. The over-all labor efficiency in the receiving room can be expressed in terms of man-minutes required to handle 100 cans. These 100 cans represent an average truck load. The results of several dairies which were studied are listed in Table 4, with the theoretical expected labor requirements for the number of men being employed for the operation. The major causes for delays are listed under Table 4, which illustrate the main difficulties in the receiving room. Each of the major pieces of equipment, the conveyor, weigh can and can washer must be properly selected, arranged, and used for an efficient receiving operation.

Soil Compaction

(Continued from page 831)

jack is then used to compact the soil to a density of 1.50 after which it is again probed. The results are somewhat dramatic since about three times as much weight is now required. Possibly the most important result is that pressure of the jack on the surface compacted the entire 13-in depth of the profile that is reached by the probe. This fact is stressed since it shows that the compaction which may be developed by wheel traffic extends far below plow depth. Therefore, compaction will not be removed by subsequent tillage operations. Free's data showing the effect of compaction on permeability are then placed on a blackboard and discussed. The demonstration is concluded by summarizing the following points:

1 Excessive soil compaction reduces water intake and crop yields.

2 It is difficult to loosen compacted soil since it extends deeper than the furrow slice and deep-tillage implements seem to have little lasting effect.

3 Prevention is better than cure.

4 To prevent soil compaction, (a) do not work soil when it is wet, (b) do not overfit a seedbed, (c) avoid unnecessary wheel traffic, and (d) maintain a reasonable level of soil organic matter.

The Cornell penetrometer, which makes it possible for people to see what is taking place, is responsible for the attention which this demonstration has received. The self-recording feature of the penetrometer also facilitates research studies since no time-consuming calculations are required. To check the accuracy of the findings core samples have been taken on numerous occasions and tested for permeability and volume weight. In all cases it was found that differences shown by the penetrometer actually existed. For example, in one potato field probing the soil in wheel track rows required 20 lb more pressure than was needed in the non-wheel rows. Laboratory tests showed the permeability rate of the former to be less than half that of the latter.

However, the penetrometer like other devices has its limitations. The most accurate results are obtained when the moisture content of the soil is about 20 percent. In saturated soil little force is recorded even on compacted soil. Under dry conditions the soil may be so hard that the probe cannot be entered. This difficulty could be overcome with heavier machine operated equipment. Areas to be compared should have nearly the same moisture content. No conclusions can be reached by comparing the results obtained on a sandy soil with those found on a clay soil, since there is a natural difference in volume density and other physical properties. Under stony conditions it is desirable to make several tests and average the results.

SUMMARY

The Cornell soil penetrometer is effective in demonstrating the cause and effect of soil compaction and is useful in research and exploratory studies. Its principal advantage over hammer-type penetrometers is that it is self-recording and no calculations are needed to interpret results. It is an excellent teaching device. The results obtained in field studies seem to be reliable. An elementary knowledge of soil physics and a little common sense are all that are required to use it.

APPENDIX

ONE METHOD OF CALCULATING SOIL DENSITY

By Hugh M. Wilson

Soil density, or compaction, is measured by comparing the weight of a given amount of soil with the weight of the same volume of water. When a given amount of water weighs 1 lb, the same volume of dry soil may weigh from 1.25 to 1.60 lb, depending upon its organic content, texture and degree of campaction.

The following figures and calculations were used to determine the volume weight of soil in a test pipe:

The cross section area of the test pipe = 30.3 sq in
Volume of 18-in length of the test pipe = 527 cu in

One cubic foot of water weighs 62.5 lb
One cubic foot of soil (volume weight, 1.25) = 78.1 lb
One cubic foot of soil (volume weight, 1.30) = 81.3 lb
One cubic foot of soil (volume weight, 1.35) = 84.4 lb
One cubic foot of soil (volume weight, 1.40) = 87.5 lb
One cubic foot of soil (volume weight, 1.50) = 93.8 lb
One cubic foot of soil (volume weight, 1.60) = 100.0 lb

The weight of soil in one linear inch of the test pipe was determined by proportion. For example, a cubic foot (1728 cu in) of soil with a volume density of 1.25 would weigh 78 lb. Therefore,

$$1728 : 29.3 = 78 : x \; ; x = 1.32$$

The following table shows the volume density when a given amount of soil is packed into the tube at varying depths:

Volume weight	Weight lineal inch	Pounds of soil in tube at varying depths and rates of compaction					
		13 in	14 in	15 in	16 in	17 in	18 in
1.00	1.06	13.8	14.8	15.9	17.0	18.0	19.1
1.25	1.32	17.1	18.5	19.8	21.1	22.4	23.8
1.30	1.38	17.9	19.3	20.7	22.0	23.5	24.8
1.35	1.43	18.6	20.0	21.5	22.9	24.3	25.8
1.40	1.48	19.3	20.7	22.2	23.7	25.2	26.6
1.50	1.59	20.7	22.3	23.8	25.5	27.0	28.6
1.60	1.7	22.0	23.8	25.5	27.2	28.9	30.6

Water Storage Efficiency

Vaughn E. Hansen
MEMBER ASAE

MUCH good has resulted from the concept of water-application efficiency defined by Israelsen (1)*, as "the ratio of the volume of water that is stored by the irrigator in the soil root zone and ultimately consumed (transpired or evaporated or both) to the volume of water delivered to the farm." Israelsen's proposed formula is

$$E_a = 100\ (W_s/W_f)$$

in which E_a = water application efficiency

W_s = irrigation water stored in the root zone of the soil on the farm

W_f = irrigation water delivered to the farm.

This formula focuses attention on the efficiency of application – a subject needing considerable attention in most irrigated areas.

The author proposes to go a step further, without neglecting the importance of water-application efficiency, and focuses attention upon the efficiency of storage of water.

Indications of inadequate water storage can be observed readily in traveling through almost any irrigated area. Dry spots in irrigated fields, evidenced by wilted foliage resulting from poor water distribution are all too common. Lack of uniformity of vegetative cover is another indication. The results of poor distribution of irrigation water are serious enough to justify land leveling costs of from $50 to $100 or more an acre to improve the distribution. It doesn't take many low-production areas in a field such as shown in Fig. 1 to wipe out the farmer's profit.

Even though uniform distribution of water is essential for efficient irrigation practices, we have not yet developed a quantitative method of evaluating the completeness with which we have filled the soil-moisture reservoir. Water-application efficiency evaluates the application in terms of how much water was used over and above what was required. The following development proposes a quantitative evaluation of the adequacy with which we fill the soil-moisture reservoir during the irrigation.

Attention is focused upon the storage efficiency through the use of the following formula to evaluate the water-storage efficiency:

$$E_s = 100\ (W_s/W_n) \quad \ldots\ldots\ldots \quad [1]$$

in which E_s = water-storage efficiency

W_s = water stored in the root zone during the irrigation

W_n = water needed in the root zone prior to the irrigation.

It will be noted that the definition of water-storage efficiency does not concern itself with the water which is not stored in the root zone. The entire attention is focused upon how completely the root zone is filled by the irrigation water. The denominator of the water-storage efficiency formula is the water needed in the root zone prior to the irrigation.

Equation [1] modified into the following form will be useful in a rapid field determination of water-storage efficiency:

$$E_s = 100 \frac{A - ae}{A}$$

or

$$E_s = 100\ (1 - ae/A) \quad \ldots\ldots\ldots \quad [2]$$

in which E_s = the water-storage efficiency

A = the total area of the irrigated field

a = area of the field receiving a deficient irrigation

e = ratio of the moisture deficiency in the root zone of the soil following the irrigation to the moisture deficiency prior to the irrigation.

If sections of the field received varying amounts of water, then let $a_1, a_2, a_3, \ldots a_i \ldots a_n$ = areas of the field receiving a deficient irrigation and $e_1, e_2, e_3, \ldots e_i \ldots e_n$ =

This paper was presented at a meeting of the Rocky Mountain Section of the American Society of Agricultural Engineers at Laramie, Wyo., April, 1953. It is a report of the research developed under the Research and Marketing Act, Project W-9, cooperatively with the Utah Agricultural Experiment Station, the irrigation division, Soil Conservation Service, and the Bureau of Plant Industry, Soils, and Agricultural Engineering, U.S. Department of Agriculture.

The author — VAUGHN E. HANSEN — is irrigation engineer (BPISAE), U.S. Department of Agriculture, and research associate professor, Utah Agricultural Experiment Station.

*Numbers in parentheses refer to the appended references.

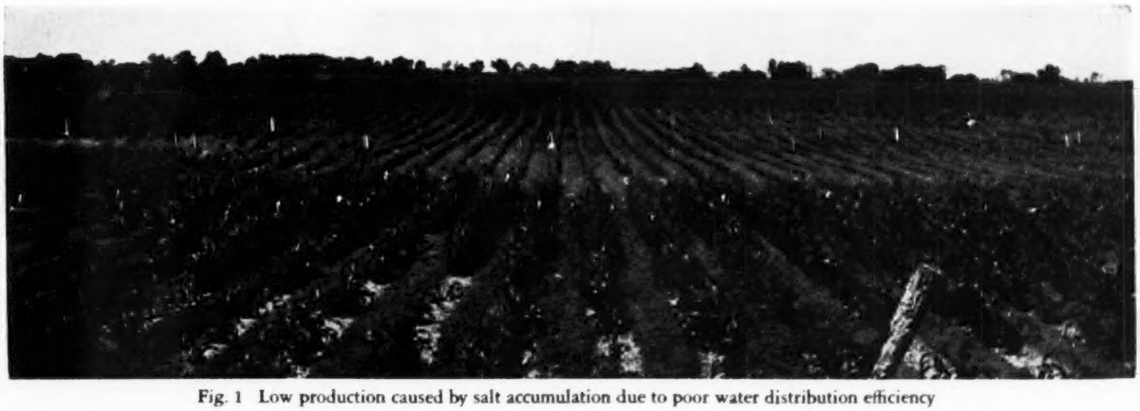

Fig. 1 Low production caused by salt accumulation due to poor water distribution efficiency

the ratio of the moisture deficiency in the root zone of the soil following the irrigation to the moisture deficiency prior to the irrigation on areas $a_1, a_2, a_3, \ldots a_i \ldots a_n$, respectively. Then the equation for water storage efficiency can be expressed in the more general form as

$$E_s = 100\,(1 - \sum_{1}^{n} a_i e_i / A) \quad . \; . \; . \; . \; . \; . \; . \; . \quad [3]$$

As an example of the use of the above formula, suppose six acres were to be irrigated, and the needed depth is 4 in of water in the root-zone soil. If two acres of the six received only a 1-in depth instead of the needed 4 in, then the water-storage efficiency would be, using equation [1],

$$E_s = 100\,(W_s/W_n)$$
$$= 100\,(4\times4+2\times1)/(6\times4)$$
$$E_s = 75 \text{ percent}$$

or using equation [2], $E_s = 100\,(1 - ae/A)$

$$= 100\,(1 - 2\times{}^3\!/_4/6)$$
$$E_s = 75 \text{ percent}$$

To assist in evaluating water-storage efficiency, it is suggested that the following concepts be kept in mind. Of considerable practical significance, both to the field technician and often to the researcher, is the fact that a precise evaluation of irriation efficiency usually has little regional value. A good estimate of the average efficiency in an area and an estimate of the general condition related to this efficiency is far more valuable than a few "precise" measurements on given farms that in themselves may not be representative of the area because of operational, cultural, topographic, or soil conditions. The word "precise" is used with quotation marks because detailed studies have shown that today even the best methods for determining soil moisture when applied to a field scale involve considerable experimental and sampling error.

It should be stressed that, in general, to be able to determine the efficiency of irrigation to within ±15 percent on a large number of locations and hence obtain a representative farm area is more valuable than to determine the efficiency to within ±5 percent on a few farms that may not and probably are not representative of the region. Those using the concepts of irrigation efficiency should keep constantly in mind the reason for determining efficiency, the accuracy of that determination, and its application.

Applying these concepts to water-storage efficiency, it is seen that considerable time and energy could be expended determining the "exact" size of each differential area; it is easy to see that one could waste a great deal of time accumulating data that had little meaning. On the other hand, the person looking at the field as a whole could see a definite, rather distinct, pattern of water-storage efficiency. The area involved could be estimated by pacing and the extent of the moisture deficiency determined in the field with the soil auger and chart relating the appearance and feel to the approximate soil moisture. For most practical purposes an estimate of the water-storage efficiency could be made on a ten-acre field in an hour or less. In general, farm irrigation practice is not developed to the stage of perfection demanding "precise" measurements of irrigation efficiencies; estimates usually leave ample room for improvement of irrigation practice.

EXAMPLES OF USE OF STORAGE EFFICIENCY

There are several types of irrigation practice in which the efficiency of storage is an important measuring stick. For instance, in sprinkler irrigation is noted for uneven distribution and insufficient application to fill the root zone with the required water are major problems. Since there is no runoff and usually slight deep percolation loss, the water-application efficiency is high; however, the irrigation practice might be poor resulting in poor yields because of failure to apply sufficient water to fill the root zone. Consequently the water-storage efficiency would be a better measure of the irrigation practice in this case than would water-application efficiency.

Another case where water-storage efficiency becomes exceedingly important is on those lands of uneven topography, inadequate water control, poor management, or combinations of these conditions resulting in uneven surface distribution.

On lands having a salt problem, it is good irrigation practice to apply more water than is needed to fill the root zone. The excess water moving beyond the root zone carries dissolved salts with it. In this case low water-application efficiency is encouraged. However, of just as vital concern is that all portions of the field receive more than enough water to fill the root zone. Poor distribution from which part of the field received insufficient water to fill the root zone would probably result in a serious salt problem on that portion of the field. Low-production areas due to inadequate leaching of excess salts are common in many irrigated areas (Fig. 1). Hence the storage efficiency is of major importance in these areas.

Some irrigated areas because of a water shortage, serious drainage problem, or excellent water control and distribution, apply water consistently at or near 100-percent efficiency. However, the higher the water-application efficiency, the greater the tendency to provide insufficient water to fill the deeper portions of the root-zone soil. Consequently in areas of high water-application efficiency, water-storage efficiency is an extremely important concept. An excellent example of this condition is in the Lower Rio Grande Valley of Texas where improved water distribution has been shown to triple production (3). In western Kansas, improved water-distribution efficiency has resulted in double the production (2). In both of these areas the water-application efficiency is very high.

In the above listed cases as well as several others, the major weakness in the irrigation practice can be quantitatively evaluated by use of the water-storage efficiency concept.

CONCLUSION

The concept of water-storage efficiency is proposed as a step beyond the commonly used concept of water-application efficiency. Even though water-application efficiency might frequently be a satisfactory index of irrigation practice, poor distribution of the water within the field or inadequate applications is often a major cause of poor irrigation practice. Neither aspect of the efficiency of irrigation can be neglected, if the farmer is going to have maximum production. For most practical purposes, estimates of the water-storage efficiency can be made with a minimum expenditure of both time and money. The data thus gained can be of considerable help in measuring and improving irrigation practice.

(Continued on page 842)

Hydraulic Characteristics of Pipe Systems for Irrigation Enterprises

A. F. Pillsbury and E. H. Taylor
MEMBER ASAE

CONCRETE pipe systems for the distribution of irrigation water by irrigation districts are still in their infancy. Higher cost of water, higher value land, and need for more efficient delivery and usage dictates increasing attention to such pipe systems. We have therefore been interested in investigating the several possible types of systems, determining to what extent they provide a certain flexibility required by the farmer, determining whether or not a high "load factor" is possible for reasons of economy, determining their characteristics from the viewpoint of operational economy, and, most important, determining their hydraulic characteristics from the viewpoints of design and steadiness of flow.

As previously discussed (1)*, there are three probable types of systems: the closed or pressure system, the open system, and the semiclosed system. A general discussion of each type of system follows.

Closed Systems. The closed or pressure system is the conventional type for the distribution of domestic water. It is rarely designed for irrigation service, although there are many systems in southern California which are for a combination of domestic and irrigation service. Its use in some instances might involve water-hammer problems, but no investigation of this is now included by the authors. Costs of the pressure pipe required have generally precluded its use. To avoid overload, the number of deliveries open at any one time can be regulated. Deliveries, however, with anything like a high load factor on the system, would be subject to considerable fluctuation. Downstream control float valves might correct this, and could be installed to give the farmer more flexibility in his delivery.

Open Systems. With open systems there is an overflow stand at periodic intervals (Fig. 1). Deliveries are made from the upstream portion of each stand, presumably at a near constant head and hence at steady flow. For good service, there must be provision to discharge regulatory waste at the end of each lateral. Otherwise the last delivery absorbs all regulatory fluctuations. It has long been known that such systems have an inherent instability associated with the entrainment of air (2). It is known that the late S. H. Beckett of the University of California (Davis) in the 1920's designed vents and also sloping downpour sections which eliminated the difficulty, but no record of published accounts of the work has been found. Curtis (3) reports that the U. S. Bureau of Reclamation has found surge to be amplified in successive reaches of pipe, and has made an approximate mathematical analysis of such flow characteristics.

At the University of California (Los Angeles), the authors have set up a model of an open system on approx-

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The authors — A. F. PILLSBURY and E. H. TAYLOR — are, respectively, professor of irrigation and associate professor of engineering, University of California, Los Angeles.

*Numbers in parentheses refer to the appended references.

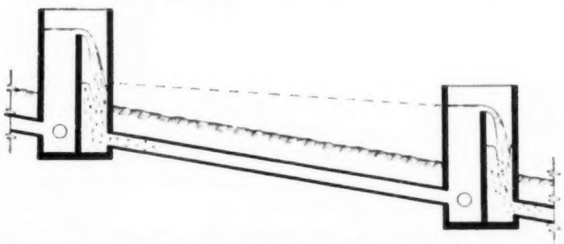

Fig. 1 Portion of an open-pipe system showing overflow stand at periodic intervals. Deliveries are normally made from the upstream portion of each stand

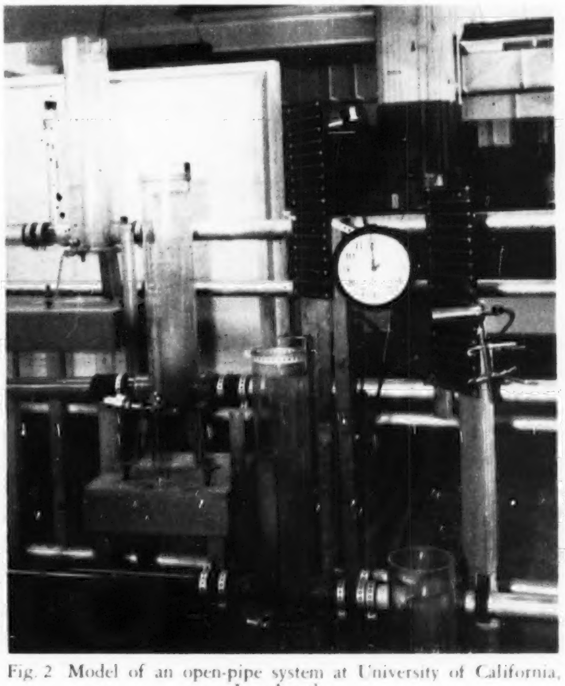

Fig. 2 Model of an open-pipe system at University of California, Los Angeles

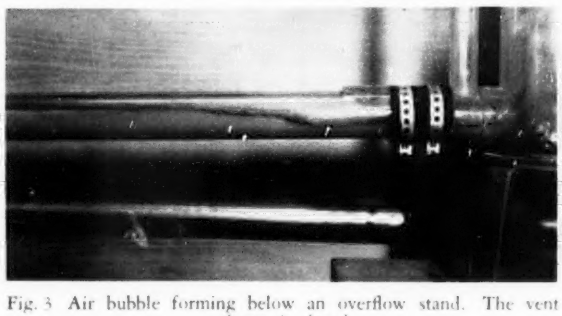

Fig. 3 Air bubble forming below an overflow stand. The vent shown is closed

imately 1/12 scale (Fig. 2). Parts of this are of plastic, enabling us to observe the entrainment of air, the initiation of surge, and a venting design which corrected the surge initiation encountered. In addition, the system is being used to verify a rather complete analysis of the flow characteristics of an open system†. The analysis is summarized later in this paper‡.

The incidence of surge which we observed in the model resulted from the gradual buildup of an air pocket in the extreme upstream reach of pipe, which periodically blew back into the stand (Fig. 3). The surge initiated was not serious, but the amplification in successive reaches downstream was. Not yet having completed our work, we are not prepared to say whether or not this is the only type of surge initiation that takes place in some of the prototypes.

In the model, placement of large vents immediately downstream from each overflow stand prevented any surge initiation. However, when surge was imposed upon the system from outside by any change in flow rate, both rates being steady, surge was amplified as before venting, but dampened out in about two minutes. Although vents were completely successful in preventing all surge initiation observed in the model, they were not completely successful in preventing the carrying of considerable air into the system at high flows, which appears to adversely affect the friction loss. We have been unable to get full flow through the system as yet. A second smaller vent some distance downstream may help in this respect.

Vents of course should be as close to each stand as possible. They should be of large size. We recommend that they be of the full size, or near the full size, of the pipe line to the top. As can be seen from the analysis to follow, there is an inverse relationship between the amplification of surge and the area of the upstream reservoir of each reach (the downstream portion of the stands). Vents serve to increase such area in addition to releasing the air.

†To the best of the authors' knowledge, the analysis of the USBR is unpublished; they therefore made one of their own.

‡Details of the analysis have been duplicated and can be obtained from the authors.

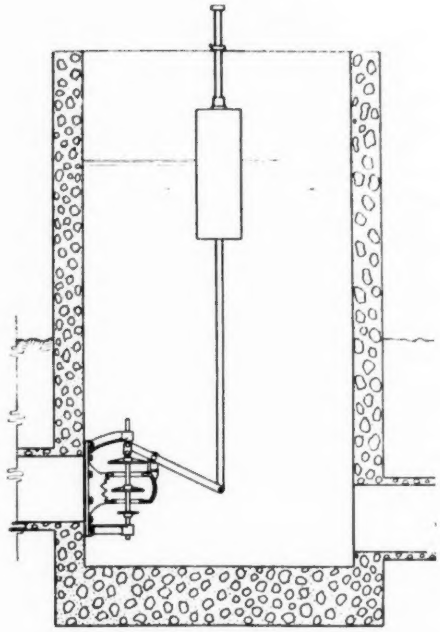

Fig. 4 A float valve stand

The measures above suggested may make the open systems now installed more successful. The system, however, has inherent weaknesses, and we suggest that engineers design no more of this type.

Semiclosed Systems. The semiclosed system simply substitutes a float valve with downstream control for the baffle in each overflow stand of an open system (Fig. 4). It therefore takes on the essential operating characteristics of the closed system except that pipe line pressures never exceed the value established by the water surface in the next stand upstream. Thus low-pressure pipe can be used. Only the water which is delivered flows down the system; so

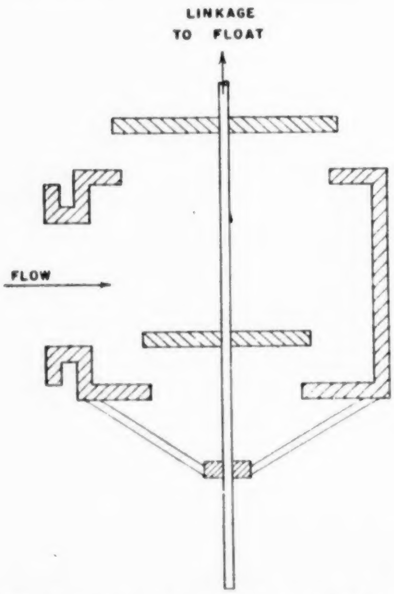

Fig. 5 Diagrammatic cross section of a double-disk, balanced. float valve

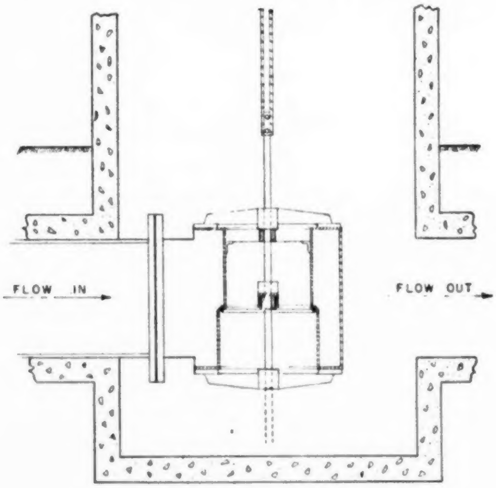

Fig. 6 Sketch of a cylinder-type float valve

there is no regulatory waste involved, provided there is storage or control all the way upstream. Deliveries can be kept at essentially a constant rate unless the capacity of the system is exceeded. If desired, however, farmers can vary their flows at will without causing operating problems as far upstream as the automatic feature is provided. Operation can be completely automatic. There is no opportunity for air entrainment.

Without air entrainment, and with correct design, the semiclosed system provides positive stability in operation. "Hunting" of float valves in series is a very real possibility if design is not correct. If the oscillatory properties of the float and valve happen to be matched in just the right way to the characteristics of the pipe and stands, series surging can result. In a previous paper (4) the authors drew certain conclusions regarding the stability of a single float valve without regard to the inertia effects of the water in the pipe line. It was demonstrated that proper selection of the float shape and the linkage ratio, together with the ratio of the cross-sectional area of the float to the stand, could eliminate hunting completely. At the present time selection of these factors is largely by rule of thumb, and the infrequent operating difficulties have been cured by cut-and-try procedures. Such methods can suffice, but we feel that further studies offer a fruitful field of investigation that will permit more rational design. We intend to pursue such studies in the near future.

Successful conversion of open systems to semiclosed systems began on a number of farms on the steeper slopes in southern California in 1944. Some valves used had the hunting difficulties mentioned above, but most installations were remarkably successful, providing great savings in irrigation labor. There has been considerable hesitancy, however, on the part of large organizations in trying the system for district distribution. Reasons given were that friction losses through known valves were too high, and that some waters would be corrosive to metal valves. In regard to the former reason, there have been highly significant developments in the past few months.

Reason for significant developments in valves can be attributed largely to the fact that one district has gone into the design of the semiclosed system. That is the Orange Cove Irrigation District of Orange Cove, California. J. F. Sorensen, general manager and chief engineer, has tried out every float valve that has been developed, and has designed one of his own. Most valves are of the double-disk, balanced type (Fig. 5). The manufacturer of one recently reported that the U. S. Bureau of Reclamation tested his most recent designs and found the friction loss wide open to be only 0.78 velocity heads (based on nominal pipe diameter and including 0.03 velocity head loss). A cylinder valve, Fig. 6, has just been developed. No information on operating characteristics is yet available, but the valve looks promising. Reports are that it is being tested at the present time. A third type is a radial gate valve, developed, constructed, and installed by Mr. Sorensen. Data on performance are not yet available. The above gates have been developed for district systems. Valves for farm systems are discussed in the previous article (4).

The question of water hammer has been raised in regard to semiclosed systems. The factors which make for stability cause a lag in response of the valves for which a foot or two freeboard must be provided in the stand, but as observed in the field, there appears to be no appreciable hammer. Opportunity for hammer would occur with fast-closing manual valves on deliveries. Such valves can well be avoided except where deliveries are made directly from a stand. The storage in the stand can absorb most of the shock.

Analysis of Unsteady Flow in Open Systems. Open-pipe distribution systems of the type under study inherently contain oscillatory characteristics. A reach of pipe, considered together with the box stands at either end as in Fig. 7, has the property of being able to accommodate relatively large fluctuations in flow with comparatively small changes in baffle head z. This is because the baffle functions essentially as a weir, and the quantity varies with some power of z in the neighborhood of 1.5§. For purposes of illustration, we may think of the downstream level as not changing at all with changes in flow, thus likening the pipe reach to the idealized situation of Fig. 8, in which an upstream stand is connected to an infinitely large reservoir by a long "frictionless" pipe. The cross-sectional area of the stand is A and of the pipe is a, and the velocity is initially zero.

Imagine now that the equilibrium is disturbed by the sudden addition of water to the stand. The new depth measured with respect to the original level is at any time y. The dynamical equation applicable to this situation is (in the assumed absence of any loss)

$$y=(l/g)(dV/dt) \qquad [1]$$

l being the length of the pipe line, and the equation of continuity is

$$-A(dy/dt)=aV \qquad [2]$$

We differentiate the second equation

$$dV/dt=-(A/a)(d^2y/dt^2) \qquad [3]$$

§Our small scale experiments, using relatively thick plastic weir crests, in which heads of about ½ in are common, indicate an empirical relationship, $Q=Cz^n$ where n is almost 2. It is possible that capillarity is relatively more important here than would be the case with a prototype.

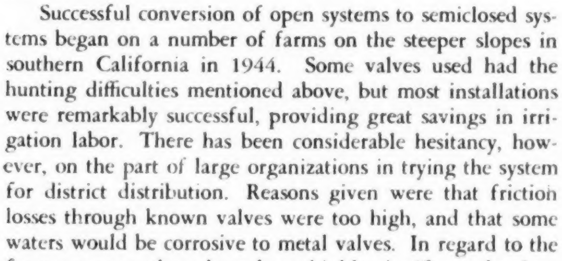

Fig. 7 A reach of open pipe

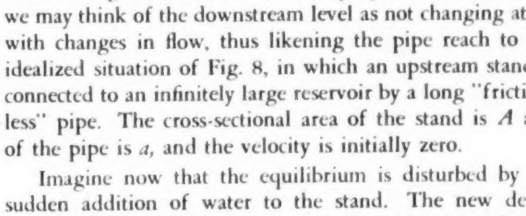

Fig. 8 A reach of open system connecting to an infinitely large reservoir

and insert this result in equation [1], obtaining

$$(d^2y/dt^2) + (ga/lA)\,y = 0 \qquad [4]$$

This equation is the well-known one of simple harmonic motion. If the depth were y_o and dy/dt was zero when time was started, the solution equation would be

$$y = y_o \cos pt \qquad [5]$$

$$\text{in which } p = \sqrt{ga/lA} \qquad [6]$$

y then is seen to vary continuously between the values $+y_o$ and $-y_o$ with a period in seconds given by

$$T = 2\pi\sqrt{lA/ga} \qquad [7]$$

The problem under consideration is, of course, more involved than this simple example. The two are sufficiently alike, however, to suggest the oscillatory property of the actual boxstand pipe line system. Friction and the fact that there is an average through-flow complicate the relationships, but, as will be seen, the same basic equations are used. It can be inferred from equation [4] that any departure from steady conditions such as a change in flow will result in at least a transient period of oscillations until friction damps it out. More important is the fact that a periodic disturbance may be of such frequency as to set the reach in resonance, thus giving rise to oscillations of large amplitude.

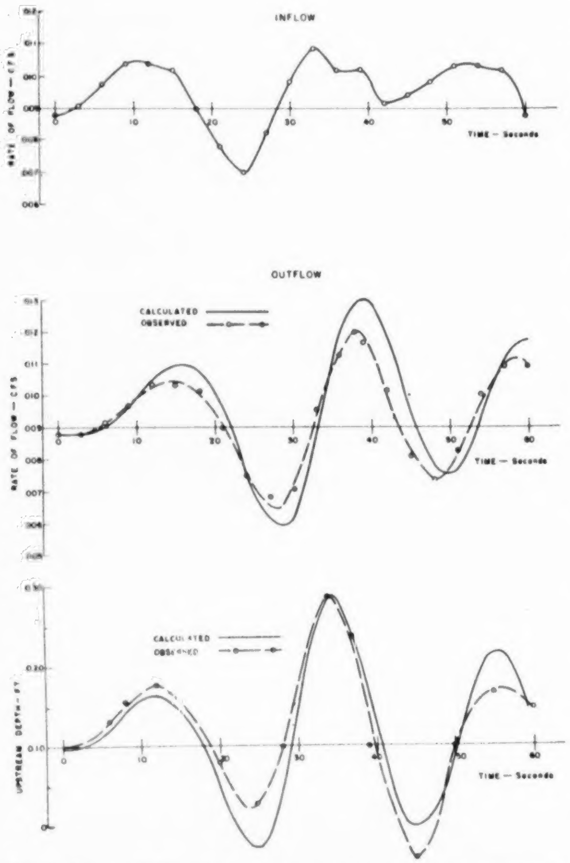

Fig. 9 Results on second reach of measurement and computation of surge amplication in model. Surge initiated at zero time

The model study indicates that a resonance phenomenon actually takes place. The process appears to occur somewhat as follows:

1 The vent is closed at the upstream stand of the first reach, permitting the periodic formation of an air pocket in the pipe directly below the stand. This bubble alternately builds up and blows back causing a small random or irregular variation in flow over the baffle in the second stand.

2 The second reach reacts to this slightly fluctuating inflow somewhat in the nature of a filter, passing principally oscillations near the natural frequency of the reach.

3 The more regular fluctuation in outflow from the second reach, which is of course, the inflow to the third, now imposes a disturbance on the third reach which is very nearly in resonance, since all three reaches were constructed alike. Thus the third reach reacts very markedly. We have noted fluctuations in water level in the downstream stand of the third reach of as much as a foot.

As a first check on the validity of the above qualitative suppositions an experiment was devised whereby the variation in inflow and outflow in the second reach of pipe could be measured. Measurements were taken for the first sixty seconds after the initiation of unsteady flow as follows:

First, all vents were opened, allowing the flow to become steady. At a given signal the vent at the first stand was closed and a photographic record was started (and maintained at three-second intervals) of the rise and fall of the water levels in the upstream and downstream stands. The stand baffles had previously been calibrated as weirs, allowing the conversion of level variation to variation in discharge. The experimental results are plotted on Fig. 9. Note the random character of the inflow in comparison with the more periodic nature of the outflow.

It was considered interesting to determine whether or not the phenomenon as observed could be subjected to rational analysis. A brief account of progress to that end follows:

Referring again to Fig. 7, the basic dynamic equation for unsteady flow is

$$y - z - kV^2 = (l/g)(dV/dt) \qquad [8]$$

Here k is an over-all resistance factor. In this equation, the contribution to the inertia of the system from the water in the stands is negligibly small. Equation [8] contains three unknowns, y, z and V, all functions of time. Two other equations arise from the continuity conditions. For the upstream stand and the pipe, continuity requires

$$Q_i - A_1\ (dy/dt) = aV \qquad [9]$$

in which Q_i is the inflow to the reach.

For the pipe and downstream stand the continuity condition is

$$Q_e + A_2\,(dz/dt) = aV \qquad [10]$$

The outflow Q_e is related to the baffle head z through a function of the form

$$Q_e = Cz^n$$

as previously noted. Thus equation [10] becomes

$$Cz^n + A_2\,(dz/dt) = aV \qquad [11]$$

(Continued on page 842)

INSTRUMENT NEWS

KARL NORRIS, Editor

Sponsored by the ASAE Committee on Instrumentation and Controls. Contributions on agricultural applications of instruments and controls and related problems are invited, and should be submitted direct to K. H. Norris, Agricultural Research Center, Beltsville, Md.

Supersensitive Thermostat

F. J. Hassler and H. B. Puckett

THE fact that essentially all biological systems and processes pertaining thereto are temperature dependent makes it necessary that this variable be accurately controlled for critical experimentation.

A proportioning or modulating type of temperature controller is recognized as an effective control arrangement. This principle operates to establish an equilibrium, at the desired temperature, between the heat input and loss from the environment under control. For applications in which the ambient conditions are changing, the proportioning circuit must be modified with the "automatic reset" feature to prevent a temperature drift in the controlled environment. Since proportioning controllers are expensive, and the automatic reset feature is necessarily an additional cost, this approach to accurate temperature control presupposes costly apparatus which renders impossible those researches requiring considerable replications.

In dealing with the problem of designing an accurate economical air temperature controller for each of a multiple set of tobacco-curing test cabinets, we worked toward the development of a highly sensitive thermostat. All known commercial thermostats were considered and a number tried. For most types it was found the sensitivity of the primary sensing elements was either inherently too low or that the switching differential was too great to afford accurate control. Other thermostats were found to have a narrow temperature range for actuation but temperature control was unsuitable because of the lag or temperature inertia of the elements.

The problem was satisfactorily solved by combining two principles, each widely used in commercial thermostats, to provide on-off control: (1) spiralled bimetal as the primary sensing element and (2) the thyratron relay to switch the working current. The apparatus is illustrated by the schematic diagram in Fig. 1.

The angular deflection of the spiral bimetal, caused by temperature change, opens and closes the biasing circuit to the grid of the thyratron. Since the contact action has to switch only approximately 6 microamperes at 6.3 volts to effect the control-grid bias, no electrical deterioration or mechanical reaction from arcing takes place at the point of contact; thus full advantage of slow make-and-break is utilized. The sensitivity of the element can be increased to meet practical demands by three approaches. The angular deflection in degrees per degree of temperature change has the following relationship:

$$A = K_{dc} L/t$$

in which A = angular deflection in degrees per degree temperature change

K_{dc} = coil deflection constant

L = active length of element in inches

t = thickness of element in inches.

Therefore, the sensitivity can be increased by lengthening the bimetal strip and/or decreasing its thickness. Mounting the spirals in pairs so that they deflect in opposition for a temperature change, with each spiral serving as a contact, doubles the sensitivity for a single element.

Since control is influenced by the matching of the temperature inertia of the primary sensing element with the heat input and loss from the system, accuracy can be achieved by altering the volume to surface ratio of the bimetal.

Using bimetal material No. 2400 (W. M. Chace Co., Detroit, Mich.) 11⅝ in long, ¼ in wide, 0.202 in thick, wound in a close spiral starting at and inside radius of curvature of approximately ⅛ in and ending with a radius of curvature 9/16 in (giving an overall spiral diameter of one inch) a temperature variation of less than $\pm$¼ F, was experienced (measured with a No. 30 thermocouple) in an environment with an air velocity of approximately 30 fpm moving perpendicular to the plane of the spiral. Temperature correction was accomplished by on-off electrical heating of 20-gage nichrome wire stretched across the air stream

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The authors — F. J. HASSLER and H. B. PUCKETT — are, respectively, associate professor of agricultural engineering, North Carolina State College, and associate agricultural engineer, division of farm electrification (BPISAE), U. S. Department of Agriculture, stationed at Tobacco Experiment Station, Oxford, N. C.

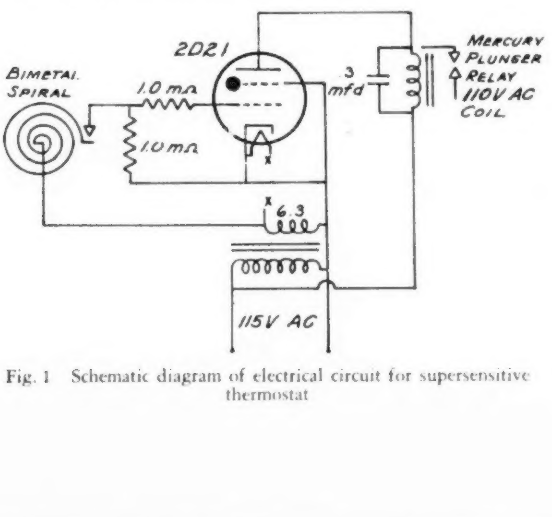

Fig. 1 Schematic diagram of electrical circuit for supersensitive thermostat

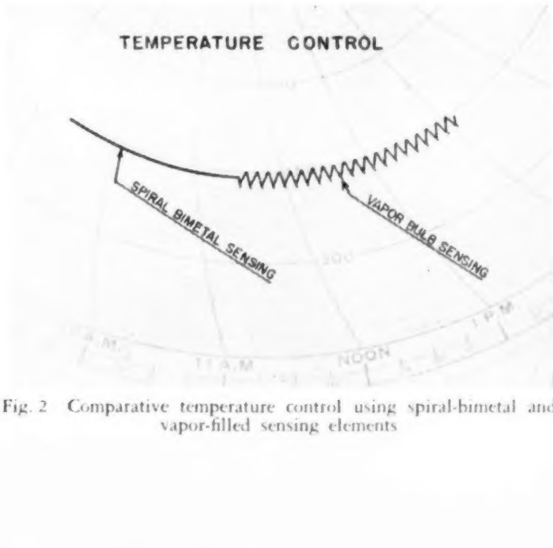

Fig. 2 Comparative temperature control using spiral-bimetal and vapor-filled sensing elements

ahead of and shielded from the bimetal spiral. Under similar conditions a commercial thermostat, employing a vapor-filled sensing element to actuate a microswitch, permitted a temperature variation of approximately ±5 F (Fig. 2).

Experience during the development proved that the contacts for the biasing circuit must remain free of corrosion. Since essentially all contact corrosion in this application results from atmospheric conditions, with no arcing or mechanical deterioration, a small amount of suitable noble metal or other inert conducting material will provide satisfactory contact points.

Because the "angular deflection per degree temperature change" ratio of the spiral is small, scale expansion must be designed into the temperature-setting arrangement to enable critical selection of temperature values in the calibration and operation of the thermostat. This was accomplished by employing a worm drive in conjunction with a radio tuning dial, giving a 70-to-1 drive ratio.

The sensitivity of this thermostat causes frequent cyclic action of the thyratron. For this reason a mercury-plunger-type relay, with proper coil and contact ratings, was used to eliminate undesirable relay noises.

Hydraulic Characteristics of Pipe

(Continued from page 840)

Equations [8], [9] and [11] now represent a simultaneous set involving the three unknowns, but unfortunately the non-linearities present in the terms kV^2 and Cz'^n preclude an analytical solution in explicit form. Therefore a stepwise numerical solution has been devised (2). It is not as satisfactory as an analytical solution in that there is no final equation from which general deductions can be made. Also, it is very tedious to apply. In brief, the method consists of calculating changes in y, z, and V which occur in small time intervals due to the fact that the inflow varies in a known manner. In Fig. 9 the comparison between the predicted outflow and the observed outflow is made. It is felt that, in view of the approximate nature of the computation together with certain possible inaccuracies in the instrumentation, the agreement is satisfactory.

The next logical step in investigating the validity of the foregoing suppositions and theory would be to subject the third reach to calculation wherein the computed outflow from the second reach becomes the disturbing influence for the third. Such a check is planned, and instrumentation is being extended so that more simultaneous data can be obtained. Solution of calculated results will be made on the differential analyzer.

Analysis of the ultimate cause of surging, namely, the quasi-periodic bubble formation will also be attempted. The present analysis accepts the fact that the second reach of pipe receives a known flow variation and then proceeds to describe results of this variation. An interesting study will be to investigate the bubble formation to determine how this influences the flow in the pipe.

CONCLUSIONS

Analyses and model studies are under way pertaining to the flow characteristics of both open and semiclosed pipe systems for irrigation water distribution. It now appears that material improvements can be made in the operation of open systems. However, the semiclosed systems, as a general rule, appear far superior in operating characteristics. We suggest that they be given careful consideration in all future plans for pipe distribution systems.

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Water Storage Efficiency

(Continued from page 836)

The water-storage efficiency concept is particularly useful in sprinkler irrigation, on lands of uneven topography or poor irrigation control or management resulting in poor surface distribution of the water, on lands being irrigated with a high water-application efficiency, or on lands consistently requiring a uniform, excess application of water to keep the salt level below the toxic range.

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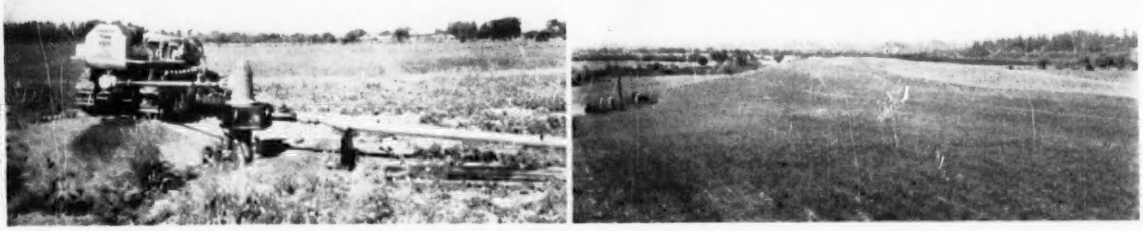


The land shown in these pictures was an old vineyard in Sonoma County, Calif., that has been converted into an irrigated pasture. In the foreground (left) is shown a Caterpillar D2 tractor driving a Byron Jackson deep-well pump through a rear power take-off which is capable of delivering water to the 36 sprinklers in the 48-acre area to be irrigated, at a rate of 252 gpm. The sprinklers are shown in action in the right-hand view

NEWS SECTION

More A-E Curriculums Accredited

AGRICULTURAL engineering curriculums recently accredited for the first time by the Engineers' Council for Professional Development (ECPD) are those offered by the agricultural engineering departments at Alabama Polytechnic Institute, Clemson Agricultural College, and West Virginia University. Reinspection and reaccrediting of the agricultural engineering curriculum at the A & M College of Texas for a period of five years is reported by F. R. Jones, head of the department.

At Alabama the four-year curriculum is administered by the college of agriculture, but students receive their basic engineering instruction in the school of engineering. F. A. Kummer is head of the agricultural engineering department. At Clemson and West Virginia the curriculums also cover a four-year period, and are each administered jointly by the college of engineering and the college of agriculture. Geo. B. Nutt and A. D. Longhouse, respectively, are the department heads.

Concrete Pipe Association Meetings

A ONE-DAY meeting of the American Concrete Agricultural Pipe Association at the Fairmont Hotel, San Francisco, on February 24, 1954, will precede a three-day meeting of the American Concrete Pipe Association at the same place, on February 25, 26 and 27, according to announcement by Howard F. Peckworth, managing director of both associations.

Penn Student Branch Cabin Party

A CABIN party marked the opening of activities of the Pennsylvania Student Branch of ASAE for the new school year. It was arranged with the cooperation of the New Holland Machine Division of The Sperry Corp.

Eighty-five undergraduates, faculty, and representatives of the New Holland organization joined in a program including football, softball, horseshoe pitching, a chicken dinner, and short talks. John Zahradnik, a 1950 graduate of Penn State, presented an illustrated talk on his recent work in Iran. Lawrence H. Skromme, chief engineer, and A. S. Marburger, vice-president, of the New Holland organization spoke briefly from their viewpoint and experience as agricultural engineering graduates associated with the farm equipment industry.

ASAE Meetings Calendar

January 22 and 23 — PACIFIC COAST SECTION, Stockton, Calif.

January 22—IOWA-ILLINOIS SECTION, American Legion Club, East Moline, Ill.

January 22 and 23—NORTH CAROLINA SECTION, North Carolina State College, Raleigh

February 1-3—SOUTHEAST and SOUTHWEST SECTIONS, Baker Hotel, Dallas, Tex.

February 13—MICHIGAN SECTION, Jackson, Mich.

April 2 and 3 — ROCKY MOUNTAIN SECTION, Colorado A. and M. College, Fort Collins

June 20-23—47TH ANNUAL MEETING, University of Minnesota, Minneapolis

NOTE: Information on the above meetings, including copies of programs, etc., will be sent on request to ASAE, St. Joseph, Mich.

Michigan Section Dearborn Meeting

A WIDE range of subject matter was covered in the fall meeting of the Michigan Section of the American Society of Agricultural Engineers at Dearborn, October 24. More than 50 members and guests were present.

In opening the meeting, Wm. G. Buchinger, chairman of the Section, announced that its winter meeting will be held at Jackson at a time to be announced later.

C. B. Richey, program chairman, introduced Lee Elfes, Massey-Harris-Ferguson, Ltd., who presented a paper on "High-Speed Mower Design."

"Field Results with Prefabricated Drying Buildings" was the title of a paper presented by David B. Poor, Stran-Steel Division, Great Lakes Steel Corp.

Speaking on the subject "Equipment Used in Bulk Milk Handling," C. W. Hall, Michigan State College, reported on a bulk-milk-handling operation near Midland.

Edwin W. Tanquary, president of ASAE, commended the group on its activity and emphasized the importance of the contacts and exchange of ideas developed by section meetings.

Reporting on the subject "Trends in Forage Handling and Storage," R. G. White, Michigan State College, noted expanding production of baled hay, chopped hay and grass silage, and decreasing output of long loose hay.

Group lunches at the Dearborn Inn or elsewhere and tours of the Ford Museum and Greenfield Village completed the program.

Two views of the group enjoying chicken dinner at the Pennsylvania Student Branch cabin party

Palmer New Chairman of Connecticut Valley Section

DWARD L. PALMER, a member of the agricultural engineering staff, University of Connecticut, Storrs, was elected the new chairman of the Connecticut Valley Section of the American Society of Agricultural Engineers at a meeting of the Section held October 28 at Sturbridge, Mass. He succeeds Carl F. Libby, president of the Northeast Agricultural Engineering Service.

The Section also elected two new vice-chairmen, Arthur G. Fox, assistant to the director of agricultural development, New England Power Service Co., and Irving J. Pflug, a member of the agricultural engineering staff, University of Massachusetts. Charles F. Chunglo, agriculturist, West Massachusetts Electric Co., Springfield, was elected the new secretary-treasurer.

The national president of ASAE, E. W. Tanquary, engineering specialist, farm implement division, International Harvester Co., made a special trip to attend the meeting and spoke to the group on the particular contributions which the section organizations can make and are making to the agricultural engineering profession.

Iowa-Illinois Section Features Instrumentation and Rubber

A GROUP of 135 ASAE members and friends attended a meeting of the Iowa-Illinois Section of the American Society of Agricultural Engineers held at the American Legion Club in East Moline, Ill. on Nov. 6. The combination of an excellent dinner and program served to bring out the good attendance, which included members from distant points including Waterloo, Ames, Urbana, and Chicago. The Section chairman, C. K. Beeman, product engineer at the J. I. Case works at Burlington, Iowa, presided and introduced the two scheduled speakers. Stan Gralak, Deere and Co., made an interesting talk on instrumentation as an aid in the developing of farm machinery. He was followed by J. H. Gerstenmaier of the Goodyear Tire and Rubber Co., who gave a fine presentation on the designer's approach to the utilization of molded and extruded rubber products in machinery design.

The Section will hold four other meetings during the coming winter and spring. The second meeting is scheduled for January 22, at the same place as the meeting last month.

Farm Structures Short Course

THE department of agricultural engineering at the University of Illinois announces a farm structures short course for dealers, field men and company personnel concerned with farm buildings. The dates are January 12 to 15, 1954, and the place of registration for the course will be the Union Building on the University campus. The fee will be \$5.00. For additional details and program write Deane G. Carter, agricultural engineering department, University of Illinois, Urbana.

NEWS OF ASAE MEMBERS

Vernon H. Baker has completed the requirements for the Ph.D. degree in agricultural engineering at Michigan State College and has returned to the Agricultural Engineering Department at Virginia Polytechnic Institute, Blacksburg, as research professor of agricultural engineering.

James H. Elliott, a recent graduate in agricultural engineering, has resigned his position with the Soil Conservation Service, USDA, to accept employment as an irrigation engineer with the Arabian-American Oil Company in Saudi, Arabia. He will be located at the company's offices at Dahahran.

Biswanath Ghosh recently resigned his position with the Damodor Valley Corporation in India and entered the King's College of the Durham University, Newcastle-Upon-Tyne, England, where he will work for his master of science degree in agricultural engineering under a Burmah-Shell scholarship awarded by the Council of Scientific and Industrial Research of the Government of India.

Wayne T. Gray, a 1952 graduate in agricultural engineering, who has been on duty with the U.S. Army, has recently returned to civilian life and will be employed as a test and development engineer in the central engineering division of the Chrysler Corp., Highland Park, Mich.

Frank H. Hamlin, who has been vice-president of Papec Machine Co., Shortsville, N. Y., since 1940 and general manager since 1947, was recently named president of the company. Mr. Hamlin's connection with the company dates back to 1924. Currently he is a member of the Executive Committee of the Farm Equipment Institute, and he is a former chairman of the North Atlantic Section of ASAE.

Norton C. Ives has resigned as chief of the agricultural engineering department of the Inter-American Institute of Agricultural Sciences with headquarters at San Jose, Costa Rica, and temporarily will be employed part time on an assignment with the staff of agricultural engineers of the Farm Building and Rural Housing Division (BPISAE), U.S. Department of Agriculture, stationed at Ames, Iowa.

Vaughn C. Kegg has resigned after three years of service as product manager of Unico Products, Inc., Alliance, Ohio, to accept appointment as general manager of the Ohio Grease Co., Loudonville, Ohio.

H. M. Lapp, recently resigned as assistant agricultural extension specialist for the extension service of the Manitoba Department of Agriculture to accept appointment as assistant professor of agricultural engineering at the University of Manitoba, Winnipeg.

Charles G. McNiel recently resigned as vice-president and general manager of Wymont Tractor and Equipment Co., distributor of Ford tractors and Dearborn farm equipment at Billings, Mont., and has purchased an interest in the United Tractor and Equipment Co., Sioux Falls, S. D., Ford tractor distributors for most of South Dakota, northwest Iowa, and western Minnesota.

J. E. Metzger has resigned as sales manager of the Schanzer Mfg. Co., Lake Charles, La., to accept the position of manager of the Harvestore Division of Sprout, Waldron & Co., Muncy, Pa. He will make his headquarters at Lake Charles where he will supervise the work of Harvestore salesmen throughout the United States and Canada. In addition to sales supervision, his work will include development of the Harvestore and related equipment for application in the grain and feed industries as well as in chemical processing fields, to meet the trend toward the bulk handling and storage of products of various kinds used by processors and manufacturers.

John C. Keplinger was recently elected president of the Hercules Motors Corp., Canton, Ohio, manufacturers of gasoline and diesel engines. Mr. Keplinger joined the Hercules organization in 1926 as sales manager, becoming vice-president in charge of sales in 1931. In 1934, he was elected a member of the board of directors, and he became executive vice-president in 1948. Mr. Keplinger is an engineering graduate of Cornell University and has been a member of ASAE since 1932.


J. C. Keplinger

Lee E. Woodruff has resigned as agricultural engineer of the Skelley Oil Co., to accept a position as agricultural engineer with the Green Giant Co., LeSueur, Minn.

NECROLOGY

IRVIN D. MAYER, associate in agricultural engineering, Purdue Agricultural Experiment Station, passed away unexpectedly November 14.

Born in Chicago, he grew up and received his elementary and secondary education in Indianapolis. After receiving his bachelor's degree in civil engineering at Purdue University in 1916 and early junior engineering employment, he began directing his engineering toward agricultural applications, first in barberry eradication work, in agricultural extension in Canada, and with the Portland Cement Association.

He also earned a bachelor's degree in agriculture at Purdue University in 1919. Returning in 1921 for employment with the experiment station, he continued in active service there until his passing, with the exception of a one-year leave of absence in 1945-46 for special work with the U.S. Department of Agriculture. Completing requirements for his master's degree in 1930, he earned promotion in 1931 to the rank of associate professor and was given added responsibilities in agricultural extension. His work made him well known throughout Indiana and nationally known among agricultural engineers. Mr. Mayer's special fields were farm structures and soil and water control, but he was willing and able to apply his engineering in the interest of agriculture in other ways as well. In recent years he had contributed materially to the development of harvesting wheat straw for use in making paper board, and to agricultural engineering interest and progress in farm work simplification.

A member of ASAE since 1921, he was active in all of its divisions and on many of its committees, and a frequent contributor to its meeting programs. He served a year as chairman of the Society's Soil and Water Division in 1940-41. He was also active in the Central Presbyterian Church of Lafayette, and in the Masonic order. He is survived by his widow, Mrs. Charlotte Mayer, a son and two daughters, his mother, and a brother and sister.

NEW BOOKS

PLANNING FARM BUILDINGS, by John C. Wooley. (Third edition). Cloth, x + 303 pages, 6 x 9 inches. Illustrated and indexed. McGraw-Hill Book Co., Inc., (330 West 42nd St., New York 36, N. Y.) $5.00.

This brings up to date another text and reference in the agricultural engineering series published with Quincy C. Ayres as consulting editor. It recognizes progress made in the past few years in knowledge of environmental requirements, sanitation, functional planning, labor-saving arrangements and equipment, and structural materials and methods. Chapters cover new farming practices and equipment affecting buildings; planning buildings for size and quality; estimating the cost of new and value of old buildings; protecting the investment in farm buildings; expressing ideas in the form of sketches and of working and illustrative drawings; planning a working environment for the dairy cow; planning buildings that will contribute to the production of high-quality milk; planning housing for young dairy stock; planning dairy buildings and equipment for efficiency in daily operation; planning for the intermittent and seasonal operations that support the daily routine; planning housing for the beef-cattle enterprise; planning buildings for the hog enterprise; planning housing for the farm poultry flock; planning housing for a broiler-, egg-, or turkey-production enterprise; housing the sheep enterprise; planning storage for grain and forage; planning storage for machinery, supplies, and equipment; remodeling old buildings to meet new management practices; planning field and yard fencing and equipment; planning for the farm home; planning for utilities on the farm; and combining housing for the different enterprises at the farmstead.

ELECTRIC FIX-IT BOOK. Popular Mechanics Press (200 E. Ontario St., Chicago 11, Ill.) $2.00.

A practical guide to the non-professional electrical experimenter and home repair man, covering wiring and rewiring, fluorescent lamps, repairing appliances, making lamps, private telephones, burglar alarm systems, building relay circuits, zinc electroplating, making magnifiers, blinker lights, electric torches, electrical test light, candid recordings, auto engine tune-up, and porch and yard lights.

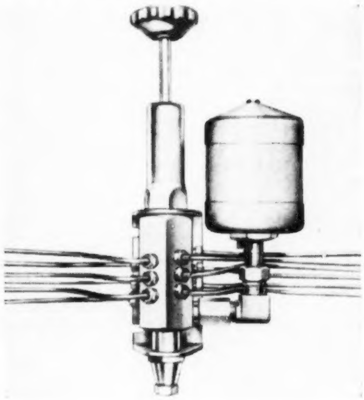
FARM PLANNERS' ENGINEERING HANDBOOK FOR THE UPPER MISSISSIPPI REGION, USDA Agricultural Handbook No. 57, by the Soil Conservation Service, Upper Mississippi Region, Regional Office, Milwaukee, Wis. Illustrated and indexed, Superintendent of Documents, Government Printing Office, Washington 25, D.C. $1.50.

Part headings are: engineering surveys, preparation of engineering data sheets, rainfall, runoff, spring and stream-flow measurements, farm ponds, springs and hydraulic rams, wells, concrete and masonry structures, terracing, diversions, vegetated outlets and water courses, land drainage, irrigation, and streambank control.

NEW PRODUCTS CATALOGS

Centralized Farm Machine Lubrication

Lincoln Engineering Co., 5701 Natural Bridge Ave., St. Louis 20, Mo., is introducing a centralized lubrication system for farm tractors and implements, under the trade name "Multi-Luber." It is being made available in kits with all necessary items ready for installation in some of the more common sizes and types of tractors; and with a guide to selection of other combina-



tions of fittings for other applications. Essentially the unit includes a lubricant reservoir, a cylinder and plunger, and tube connections to bearings. One stroke of the plunger will deliver uniform doses of lubricant through each of 12 or less ports in the cylinder, at pressures up to 2000 psi or higher. Seamless steel tubing connects the cylinder with each bearing to be lubricated;

or flexible hose is substituted where flexibility is required. Installation time is estimated at about 4 hours. Extreme pressure gear lubricants are used in the system. Use of the system is reported to result in easier, faster, better and more positive lubrication. One stroke of the plunger in each half hour of machine operation is recommended. The lubricant reservoir has a 4-oz capacity, enough for 70 hours of operation.

Fertilizer Application Bulletin

New Idea Farm Equipment Co., Coldwater, Ohio, has published for free distribution a 42-page illustrated bulletin, entitled "Fertilizer Application Guide for Major Field Crops." It recommends fertilizing and related soil-improving practices which can be aided by proper selection and use of equipment.

New Three-Point Hitch

John Deere, Moline, Ill., announces their new No. 800 three-point hitch and a large number of matched implements for John Deere Model 50, 60, and 70 tractors. A three-point hitch for the Model 40 tractor was introduced in 1952. Many implements designed for use with the No. 800 hitch are attachable from the seat of the tractor.

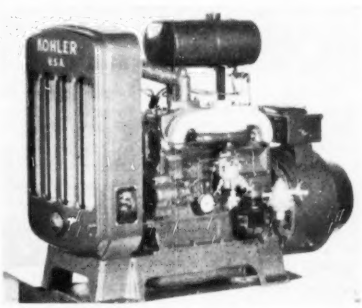
Others are attached from the ground, but telescoping draft links eliminate the need for exact positioning of the tractor, or tugging the implement into place. The new hitch is flexible; it lets integral implements trail the tractor, much the same as drawn implements, for good work not only on level land but on hillsides, along contours, over ridges, and through swales. Implements are lifted hydraulically and carried high and clear when transporting.

"Farming the Three Dimensions"

Caterpillar Tractor Co., Peoria, Ill., will send on request to interested readers a copy of the above-titled illustrated booklet (form 30824) which deals with the problem of deep tillage and the tools to break up the subsoil, including subsoilers, chisels, disk ridgers, spring shank cultivators, listers, and ditchers.

Kerosene-Operated Electric Plant

Kohler Co., Kohler, Wis., announces development of kerosene-gasoline operation for all its 2-kw and 3.5-kw manually started electric plants. The unit includes a 1¼ gal gasoline tank for starting purposes, and when the engine has reached normal operating speed and temperature, a two-way valve



transfers the fuel supply to kerosene. In effecting the engine change for this unit, the company was required to substitute a low-compression cylinder head, special intake and exhaust manifold, and modifications to the cylinder block and carburetor. The 2-kw plant shown in the illustration generates alternating current at 115 volts.

Specialized Steels for Soil Tillage

Crucible Steel Co. of America, Oliver Bldg., Pittsburgh, Pa., will send on request to interested readers a copy of an interesting and informative bulletin on the many special types of agricultural steels which it manufactures and their relation to good tillage practices. It is prefaced by an article on the place of tillage in soil improvement by a USDA authority on the subject of tillage. It also relates the different types of steel the company produces to the various operations of tillage. It also includes three important tables for design engineers: a table of disk blade concavities for which the company has forming and tempering dies, a table giving the theoretical weight of concave disks, and a radius vs. concavity table.

Light-Duty Pillow Blocks

The Fafnir Bearing Co., New Britain, Conn., will send on request descriptive literature of its recently designed new series of light-duty, ball-bearing pillow blocks, designated as type PB. These pillow blocks are a complete, ready-to-mount, economy package, which includes a separable two-piece pressed steel housing, a Fafnir wide inner-ring ball bearing with the Fafnir-originated locking collar and patented plya-seals. The housing is designed to provide initial self-alignment in all directions and to

assure ample strength for the light-duty applications for which it is recommended. Incorporated in this housing is a prelubricated Fafnir wide inner-ring ball bearing with self-locking collar. Fafnir contact-type plya-seals provide efficient grease retention and contaminant exclusion to minimize maintenance and extend bearing life.

Corrosion of Low Alloy Steels

International Nickel Co., 67 Wall St., New York 5, N. Y., will send interested readers on request copy of bulletin A-149, "Atmospheric Corrosion of Low Alloy Steels," containing 22 pages well-documented with charts and tables, reporting the effects of 9 years atmospheric exposure tests. It includes data on weight losses, pit depths, thickness measurements, calculated pitting factors, and the weight of rust on specimens. The effects of composition are discussed. On long exposure, it is shown that nickel was effective in reducing pit depth.

Locknut Bulletin

Security Locknut Corp., Melrose Park, Ill., who manufacture the Security Locknut, a patented combination of a standard nut and retainer fabricated into a single standard nut, will send on request to any reader a copy of a booklet which it has recently issued illustrating the wide range of sizes the company produces. An important section of the booklet for design engineers consists of tables of specifications of the different types of nuts the company manufactures.

Large-Size Spreader

John Deere, Moline, Ill., announces the new John Deere Model N spreader built especially for large feeders and dairymen. It has a capacity of 120 bushels, power-driven beaters, ground-driven feed conveyor for a

uniform spread at any tractor speed, heavy combination wood-and-steel construction, and large wheels and tires for good ground flotation. The spreader is made to work at speeds up to 6 miles per hour, and the wheels are equipped with Timken roller bearings.

Side Dresser and Fertilizer Spreader

New Idea Farm Equipment Co., Coldwater, Ohio, announces a new five-foot rear-mounted side dresser and broadcast fertilizer spreader designed for use with Ford and Ferguson tractors, with or without cultivator. The machine has high clearance which allows cultivation and side dressing

of mature crops. Row-width adjustments range from 6 to 72 in. Drive of the new spreader is actuated off the brake drum. The machine is designed for driving inside or outside the tractor wheels according to row widths. Patented features include cam agitator and positive-control feeding mechanism of other New Idea models.

New Bucket for Tractor Shovel

Caterpillar Tractor Co., Peoria, Ill., announces a new improved standard bucket for the Caterpillar HT4 shovel. This is a two-position bucket which will provide greater flexibility because of an adjustable hitch and a deeper bowl, making the unit better adapted for either excavating or stockpile applications.

The two positions now available are achieved by changing the removable hinge on each side of the bucket to either the forward or rear-hinge point. The forward hinge point for stockpiling gives quicker tilt-back and less spillage because of a ten-degree rack-back at the ground line. A simple adjustment connecting the bucket to the rear-hinge point retains the former digging and dumping angles desirable for excavating work.

NEW BULLETINS

"Sulphate Resistance of Portland Cements, Concrete and Mortars," by Dalton G. Miller, Phillip W. Manson, and Robert T. H. Chenn. An annotated bibliography covering articles on deterioration of concrete exposed to sulphate waters and soils, as well as to sea water, acids, and other deleterious agents, sponsored by the working committee on sulphate resistance of Committee C-1 on Cement of the American Society for Testing Materials. hTe bibliography is published in mimeograph form through the courtesy of the Portland Cement Association.

Irrigation of Flue-Cured Tobacco in North Carolina, by T. V. Wilson and C. H. M. van Bavel. North Carolina State College (Raleigh) Agronomy Research Report No. 3. A progress report on three years' tobacco irrigation research including a short section on the economics of irrigating tobacco.

Laying House Ventilation, by Wm. H. Knight and Reid Merrill. University of Idaho (Moscow) Farm Electrification Leaflet No. 22, June, 1953. sUer information on insulation and fan systems.

Culvert-Pipe Grain and Seed Drier for the Farm, by J. W. Simons and L. L. Smith. Circular No. 3 (March, 1953) Georgia Agricultural Experiment Station (Athens). Describes a drier developed from commercially available components for use on the average southern farm not requiring the capacity provided by complete driers now on the market.

How to Reduce Labor, Steps, and Costs in Dairying, by Harry M. Young, Jr., and George B. Byers. Kentucky (Lexington) Extension Circular 505 (June, 1953). Practical short cuts for dairy farmers, in terms of machine milking, work routines, buildings and equipment, methods for improvement, comparison of building costs, bedding, and advantages and disadvantages of various arrangements.

Mechanization of Cotton Production, by Rex F. Colwick et al. Southern Cooperative Series Bulletin No. 33 (June, 1953). (Alabama, Arizona, Arkansas, California, Georgia, Louisiana, Mississippi, New Mexico, North Carolina, Oklahoma, South Carolina, Texas, and farm machinery division (BPISAE), USDA). (Requests for copies from outside the cooperating states should be addressed to the Mississippi Agricultural Experiment Station, State College.) A condensed report of research on the subject from the standpoints of crop residue disposal, seedbed preparation, planting, fertilization and cover crops, weed and grass control, insect control, defoliation, and harvesting.

An Electric Work Center for the Vocational Agricultural Shop, by R. N. Jones et al. Progress Report No. 107 (August, 1953) Pennsylvania Agricultural Experiment Station (State College). Brief text and illustrations showing construction and bill of materials for a compact instruction and test unit.

Two Typical Wood Frame Houses Exposed to Energy Released by Nuclear Fission, by Richard G. Kimbell and John Fies. National Lumber Manufacturers Association (Washington, D.C.). A more technical explanation and interpretation than given in general publicity at the time, on damage to test houses included in the atom bomb test March 17, 1953.

Agricultural Implements for Indian Farmers, by R. V. Ramiah and C. P. Srivastava. Indian Council of Agricultural Research (New Delhi) Review Series No. 1 (As. 8). This is a summary primarily for agricultural extension workers, of information on some of the more widely used native implements and some imported from Denmark and Japan. It deals primarily with bullock-drawn implements, but a few mechanical power driven implements are included. Plows, harrows, cultivators, drills, harvesting and threshing equipment, rice production equipment, small-scale irrigation and miscellaneous implements are covered. The authors indicate that "The quickest method of introducing and popularizing simple agricultural implements in India is by encouraging the use of better implements of one region into another."

Field Investigation of Waste Water Reclamation to Ground Water Pollution. California State Water Pollution Control Board (Sacramento) Publication No. 6 (1953). Reports an extensive study of the subject, of special interest to water short areas, showing excellent possibilities for returning to ground water the effluent of treated sewage containing a minimum of industrial wastes. For the conditions studied, the water is reported bacteriologically safe after passing through four feet or more of soil, and of satisfactory chemical quality if high concentrations of undesirable industrial wastes are not present in the raw sewage. Highly treated effluent is necessary to maintain high rates of percolation. Mosquito control is generally necessary, and algae control may be necessary.

Control of the Waterlevel in Faintly Sloping Areas, by F. Van Schagen. English language reprint from the Netherlands Journal of Agricultural Science (Utrecht) (August, 1953). A discussion of the design and application of broad-crested weirs to maintain optimum water tables for agricultural production in areas of the Netherlands which are above sea level.

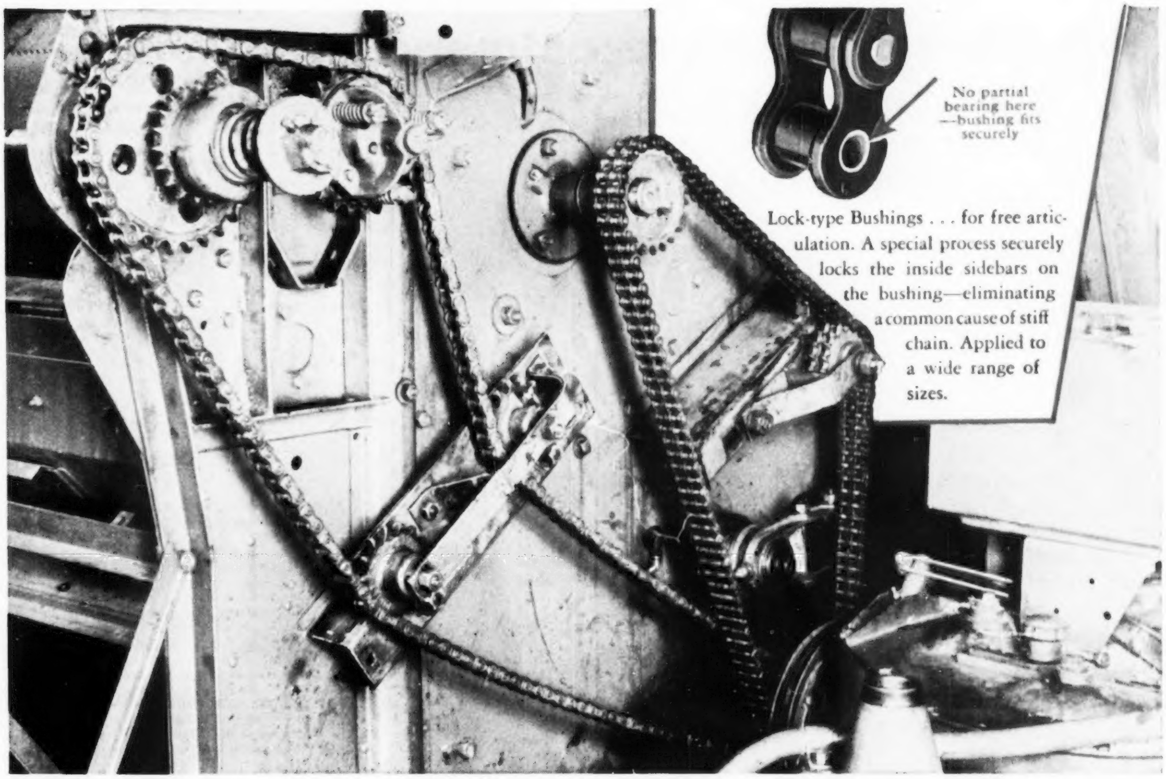
Hydraulics of Closed Conduit Spillways, Part 1. Theory and Its Application, by Fred W. Blaisdell. University of Minnesota, St. Anthony Falls Hydraulic Laboratory (Minneapolis) and Soil Conservation Service — Research USDA, Technical Paper No. 12, Series B (January, 1952). A presentation of factors influencing flow, including weirs, exits, tailwater, pipe, orifice, short tube and pressures. A means of developing a composite head-discharge curve is included.

Types of Soil Erosion Prevalent in New Zealand, by D. A. Campbell. Association Internationale d' Hydrologic Scientifique, Assemblee generale de Bruxelles 1951, Extrait du Tome II. Brief discussion of the nature and importance of simple and compound types, including variations and combinations of creep, slip, flow, sheet, gully, river and wind erosion.

Difficulties in Obtaining and Presenting Hydrologic Data, by E. C. Schnackenberg. Association Internationale d' Hydrologie Scientifique, Assemblee Generale de Bruxelles 1951, Extrait du Tome III. The author discusses problems in obtaining hydrologic data from short rivers in high rainfall areas and carrying high debris loads, characteristic of those in New Zealand, and suggests the development of international standards for related instruments and their use, so that data from various parts of the world might be more directly comparable.

Hydrologic Data, by E. C. Schnackenberg. Reprint from "Commonwealth Engineer," (Wellington, New Zealand) January-February, 1953. Part 1 on rainfall and runoff deals with standards adopted for collection of data. Part 2 deals with the design of water-level recorder structures.

(Continued on page 852)



Look to LOCK-TYPE BUSHINGS for longer roller chain life

Just one of many engineering extras you get from LINK-BELT

For drives that must operate under severe conditions, it will pay you to use Link-Belt Precision Steel Roller Chain. Lock-type bushings and the many other Link-Belt engineering extras add up to *built-in* extra life. Whether it's for power transmission or conveying, you are assured of a positive, flexible, economical chain . . . with high sustained efficiency. For complete information, see your nearby Link-Belt sales representative, or write for Engineering Data Book 2457.

LINK-BELT

ROLLER CHAINS & SPROCKETS

LINK-BELT COMPANY: Plants: Chicago, Indianapolis, Philadelphia, Colmar, Pa., Atlanta, Houston, Minneapolis, San Francisco, Los Angeles, Seattle; Scarboro, Toronto and Elmira, Ont. (Canada); Springs (South Africa); Sydney (Australia). Sales Offices in Principal Cities. 13,330

Don't overlook these other LINK-BELT extras


Shot-peened rollers have extra fatigue life under impact.

Couple and uncouple multiple-width chains more easily.

Closer heat treat control helps attain greater uniformity.

"Why do engineers recommend PRESSURE-CREOSOTED fence posts?"

● Why? Because controlled tests have proved that pressure-creosoted posts last 3 to 5 times longer than most types of untreated posts. That extra-long life reduces repair and replacement costs to a bare minimum, saving the farmer valuable time and money that he can apply to other projects on his farm.

Pressure-creosoting preserves fence posts in another way, too. Repeated grass fires that often damage untreated posts merely char the surface of pressure-creosoted posts, leaving them unharmed.

For complete details on creosote and its uses, write to Koppers Co., Inc., Tar Products Division, Pittsburgh 19, Pennsylvania.

KOPPERS COMPANY, INC., PITTSBURGH 19, PENNSYLVANIA
Tar Products Division
DISTRICT OFFICES:

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All Standard Specifications

KOPPERS CREOSOTE

The Performance-Proved Wood Preservative

PERSONNEL SERVICE BULLETIN

NOTE: In this bulletin the following listings still current and previously reported are not repeated in detail; for further information see the issue of AGRICULTURAL EGINEERING indicated.

POSITIONS OPEN—JUNE—O-147-524. JULY—O-254-526, 255-527. SEPTEMBER—O-301-530, 331-532. OCTOBER—O-348-534, 344-536, 361-537. NOVEMBER—O-341-538, 387-539, 384-540, 399-541.

POSITIONS WANTED—MAY—W-193-31, 196-32. JUNE—W-204-34, 200-36, 203-37, 220-40. JULY—W-260-42. AUGUST—W-248-45, 272-46, 278-49, 292-50, 294-52. SEPTEMBER—W-306-53, 321-54, 339-56. OCTOBER—333-57, 357-58, 359-59. NOVEMBER — W-329-60, 351-61, 356-62, 368-63, 367-64, 388-65, 369-66, 391-67, 382-68, 381-69, 394-70, 378-71, 398-72, 350-73, 404-74, 426-75.

NEW POSITIONS OPEN

DISTRICT SALES MANAGER, to supervise present dealer organization, and select and train additional dealers, for leading manufacturer of power sprayers and other specialty farm equipment. Southern territory. Graduate of southern agricultural college, with 5 yr or more of successful selling experience in the South. Usual personal qualifications for successful sales management. Married. Age 25-40. Permanent position with leading manufacturer. Salary open. Apply by letter with complete information including sales record and references. O-430-542

SALES ENGINEERS and District Managers for sales, service, and distributor and dealer training with growing manufacturer of pumps and water systems. National distribution. Territories of one or more states open from time to time. Education considered with other qualifications. Prefer experience in sale of pumps and water systems. Minimum requirements include mechanical aptitude, ability and willingness to learn, and travel Monday to Friday. Good appearance and ability to sell, gain respect of, and cooperate with wholesale distributors and dealers. Age preference depends on experience and requirements. Opportunities for advancement to junior executive and executive positions. Salary open. Proven plan for building income. Write for standard employment form. O-454-544

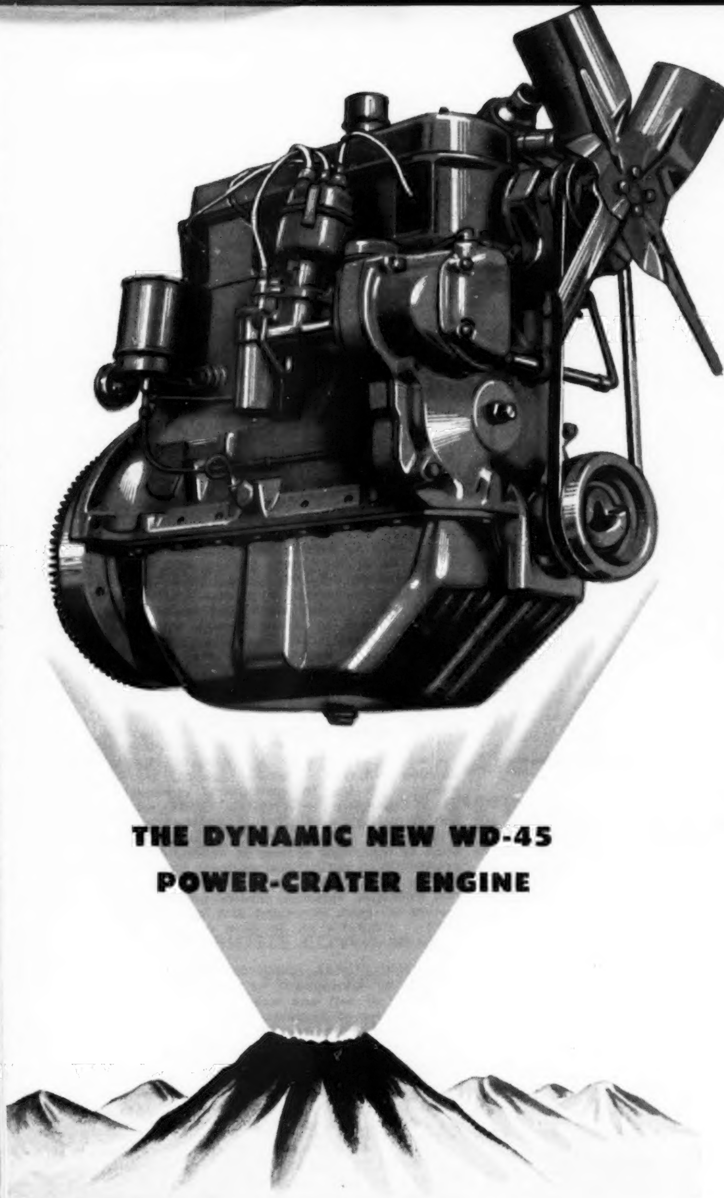
ENGINEERS AND DRAFTSMEN (2 each) for design work and product engineering on equipment for agricultural spraying and for portable irrigation, with established manufacturer. Midwest. Must have good appearance, personality, intelligence. Educational preparation, experience and age will be considered. No fixed requirement. Unlimited opportunity. Salary open. O-465-545

AGRICULTURAL ENGINEERS for design and test work with leading general line farm equipment manufacturer. Midwest location. BS deg in agricultural engineering, or equivalent, with average grades or better in mathematics, applied mechanics, and machine design, and specialization in power and machinery. Farm background. Previous experience in farm equipment design or testing desirable but not essential. Must have genuine interest and ability in design or test work; exercise good judgment and initiative; enjoy working with others; and be willing to give careful consideration to the ideas of others. Age up to 32 yr. Opportunities up to individual. Salary \$347 to \$450 mo, depending on qualifications and assignment. O-471-546

MANUFACTURERS AGENT for farm rotary snow plow in Michigan, Ohio, New York and New England. Proven winter sales item. Must be established in farm implement dealer trade. Want aggressive man with mechanical aptitude and sales ability. Age 30-40. Commission basis. O-479-547

AGRICULTURAL ENGINEER (associate rank) for research in rural housing and farm structures in a land grant college in the Southeast. MS deg in agricultural engineering, or equivalent. Architectural drafting and structural engineering experience. Pleasant and cooperative. Age, about 30. Excellent research facilities and adequate maintenance. Excellent opportunity for advancement. Salary open. O-462-548

(Continued on page 850)



THE DYNAMIC NEW WD-45
POWER-CRATER ENGINE

Power-Crater

SYMBOL OF ANOTHER FUNDAMENTAL ADVANCE IN FARM POWER BY ALLIS-CHALMERS

Yes, *POWER-CRATER!* Mark that name, because you're going to hear it often in the years to come. It's the symbol of a new standard in tractor power — the name of the mighty Allis-Chalmers engine that powers the DYNAMIC NEW WD-45 TRACTOR.

Here is *farm* power engineered in the same pioneering spirit as the rubber-tired tractor introduced by Allis-Chalmers two decades ago . . . *farm* power that keeps pace with striking new developments in engine design . . . *farm* power that delivers high octane fuel performance on regular gasoline!

THE WD-45 TRACTOR, powered by this great new Allis-Chalmers engine, develops in excess of 20 percent more horsepower than its popular predecessor, the Model WD, with a corresponding step-up of drawbar, belt and power take-off performance.

POWER-CRATER design retains all of the basic Allis-Chalmers advantages: low engine speed, low rate of piston travel, uniform cooling with "wet" cylinder sleeves, lightning-fast governor action, efficient full pressure lubrication.

Add to these: power-shifted rear wheels, two-clutch power control, automatic traction booster, 5-way hydraulic system, 4-speed helical gear transmission, 12-28 rear tires on full-width 12-inch rims, and SNAP-COUPLER for mounted implements. *All standard equipment* — and you have practical farm power in its most advanced and useful form.

No other 3-plow tractor offers the farmer so many advantages . . . so much performance . . . at so low a dollar investment!

The dynamic new WD-45 Tractor with its mighty POWER-CRATER engine easily handles its 3-bottom mounted plow in the most stubborn soils . . . increases harvesting capacity in the heaviest crops with power take-off operated combines, forage harvesters, corn pickers and hay balers.

POWER-CRATER and SNAP-COUPLER are Allis-Chalmers trademarks.

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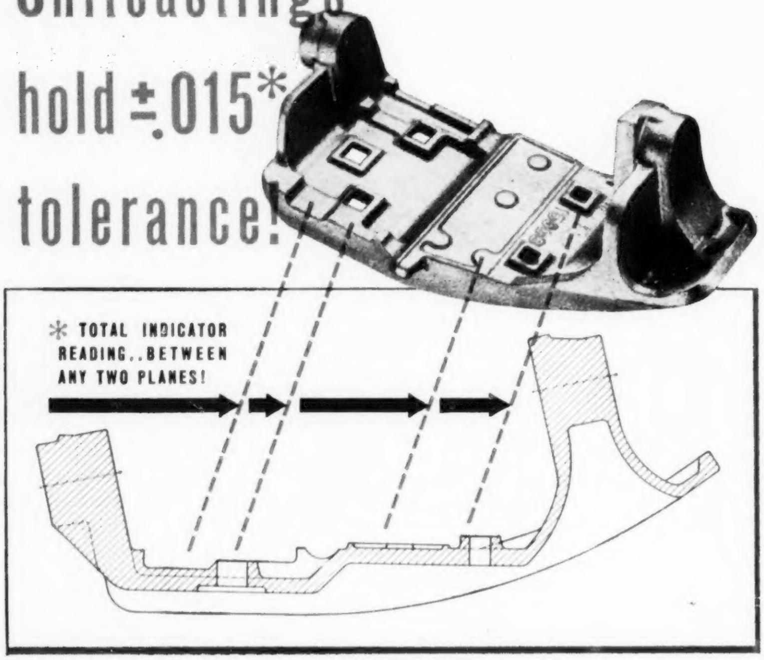
TRACTOR DIVISION · MILWAUKEE 1, U. S. A.

Unitcastings hold ±.015* tolerance!



..substantially reduces finished cost!

Functioning as an important part of a mowing machine cutter mechanism, this Inner Shoe is responsible for holding all correlated parts in alignment. Accuracy must be maintained throughout the roughest service . . . and *initial accuracy* is a "must" in reducing assembly cost!

Unitcast "foundry engineering" successfully solved the basic problems. By holding a tolerance unusual in cast steel, the necessity of machining fit surfaces was eliminated and the result . . . *less finished cost!* Practical design and experienced foundry procedure met all other requirements for durability. To date, the accumulated production figure is well over 200,000 units . . . *with less than .002% rejection!* Another example of Unitcast's ability to produce quality steel castings!

Why overlook the cost-cutting possibility in your product? A slight revision in design or specification might be beneficial. Call in Unitcast today. No obligation, of course!

UNITCAST CORPORATION - Toledo 9, Ohio

In Canada: CANADIAN-UNITCAST STEEL, LTD., Sherbrooke, Quebec

Unitcast QUALITY STEEL CASTINGS

Personnel Service Bulletin

(Continued from page 848)

NEW POSITIONS WANTED

MECHANICAL ENGINEER with 17 years experience in implement development and tractor manufacture. Last nine years spent as assistant chief engineer supervising development of seeding, planting and fertilizing equipment from design stage through testing into manufacture. Before the above spent eight years in tractor manufacture and development of service material. Open for job either in design or manufacture or work in correlating both. BS deg in mechanical engineering at Illinois Institute, two years at M.I.T. Married. Age 40. No disabilities, excellent health. Salary open. W-395-76

AGRICULTURAL ENGINEER interested in design, development, research, extension, or teaching in power and machinery, with manufacturer or public service, in Southeast or Midwest. Married. Age 25. No disability. BS deg in agricultural engineering, 1952, North Carolina State College. MS deg in agricultural engineering expected June, 1954. Farm background. Cheesemaker for Kraft Foods Co. for one year. Postwar enlisted service in Navy, 2 yr. Served as fireman and engineering record keeper on a destroyer. Worked with tobacco mechanization research project two summers and one 6-mo period. Part time drafting and design work during junior and senior years. Graduate work on stress analysis with strain gages, on several farm machines, notably forage harvesters. Available July 1. Salary $5500. W-410-77

AGRICULTURAL ENGINEER interested in design, development, research, sales, or service in farm structures or soil and water field with manufacturer, distributor, farming operation, or federal agency. Rocky Mountain or Midwest location preferred. Married. Age 31. No disability. BS deg in agricultural engineering, 1950, University of Nebraska. War enlisted service in Navy over 3 yrs. Radio operator and typist. Two summers with Nebraska department of roads and irrigation. With FHA since graduation as agricultural engineer (GS-7) preparing, checking and approving detailed plans, cost estimates, valuation reports, and inspection reports on farm structures and land improvements. Available on 30 days notice. Salary open. W-431-78

AGRICULTURAL ENGINEER—Geologist interested in development or research in farm structures or soil and water with industry in USA. Native of Argentina. Married. Age 29. No disability. Graduated as geologist, 1948, National University of La Plata; agricultural engineer, 1950, University of Buenos Aires. Experience in Soils Institute of Argentina, irrigation and fertilizer divisions, 4 yr. Currently technical adviser in forest company. Available in January. Salary, about $250 per mo. W-396-79

AGRICULTURAL ENGINEER interested in teaching, research, and development in power and machinery or processing, with college or experiment station in cotton belt. Married. Age 53. No disability. BS deg in agricultural engineering, 1930, Mississippi State College. Graduate study in trades, industrial arts, and education. Teaching shop and power machinery 12 yr. Extension work 5 yr. Research on cotton mechanization 4 yr. Foreign service in Latin America, 2-yr tour recently completed. Available now. Salary $4800. W-405-80

AGRICULTURAL ENGINEER interested in extension, teaching, or research in power and machinery with college, experiment station or manufacturer. Any location. Married. Age 28. No disability. BS deg in agricultural engineering, 1950, Louisiana State University. Sales engineering in industrial gas equipment, 12 mo. Farm equipment dealer and custom operator, 27 mo. War non-commissioned service in Army over 2½ yr. Available January 1. Salary open. W-425-81

AGRICULTURAL ENGINEER for research, teaching, or extension in rural electric or power and machinery fields with industry, experiment station or college in Southeast. Four years experience in power use and public relations field with electric cooperatives. Considerable journalistic and public speaking experience. BS deg in agricultural engineering, 1949, University of Georgia. Aviation machinist mate, U.S. Navy three years. Farm background. Ability to cooperate with fellow workers. Married. Age 29. No disability. Available on reasonable notice. Salary open. W-420-82

(Continued on page 852)

Announcing a Great New Reynolds "FIRST" Important to Farmers!

REYNOLDS *Lifetime* ALUMINUM CORRUGATED... 48" WIDE!

TWO 12' SHEETS COVER ALMOST A FULL SQUARE OF ROOF AREA... SAVES APPLICATION TIME AND MONEY!

Now build with aluminum in *less time*, with *less work*, at *less cost!* 50% fewer sheets to handle. 50% less loss of metal at side laps. And a better-looking job, too!

You know heat-reflecting aluminum boosts poultry and livestock profits... field tests prove it. You know rustproof aluminum saves money—needs no painting. Now you can get these proved advantages... at the lowest cost ever!

The new 48" Corrugated Sheets come in .024" (U. S. Std. 24 Ga.), 2½" pitch, embossed—and .019" (U. S. Std. 26 Ga.), 1¼ and 2½" pitch, plain and embossed. *Exclusive with Reynolds!*

See your dealer. Write for literature. Reynolds Metals Company, Building Products Division, Louisville 1, Kentucky.

Profit proof! Owner of this New Jersey laying house says his aluminum roof keeps "...egg production consistently high, bird mortality negligible."

MORE LOW-COST, LABOR-SAVING BUILDINGS... COMPLETE PLANS BY REYNOLDS FARM INSTITUTE

Pole Barn 52' x 60', Pole Cattle Shed 26' x 60' and *Machinery Center 26' x 60'*... all extendable by 15' sections. *10,000-bird Broiler House*, 52' x 150' and *1,500-bird Laying House*, 41' x 130' ... shortened or lengthened by 15' sections. *Pole Corn Crib* 30' x 32', extendable by 8' sections. *Portable Range Shelter* on skids, 8' x 10'. Plans at price shown in coupon include detailed drawings, erection instructions and material lists. Or check coupon for FREE descriptive literature.

FARM INSTITUTE

Reynolds Farm Institute, P.O. Box 2047
Louisville 1, Kentucky

I enclose $ ______ for complete plans of the buildings checked.

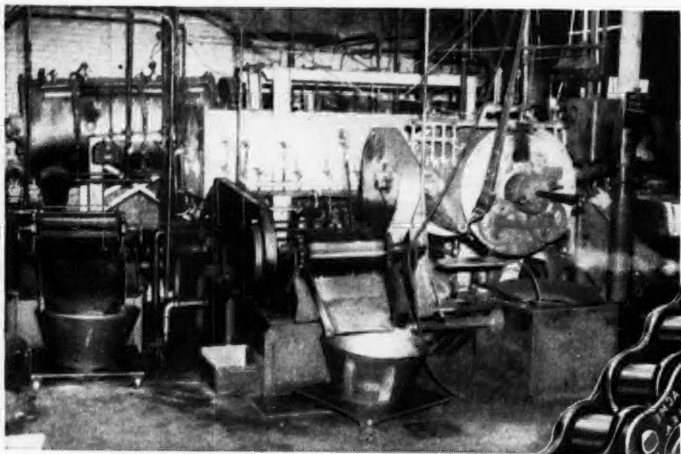
- ☐ Please send me FREE literature on buildings checked.
- ☐ Pole Barn ($1) ☐ Cattle Shed ($1)
- ☐ Machinery Center ($1) ☐ Broiler House ($1)
- ☐ Laying House ($1) ☐ Corn Crib (50c)
- ☐ Range Shelter (25c)

Name ______

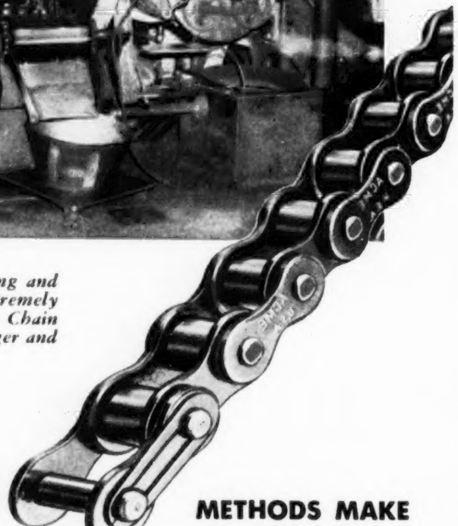
Address ______

SEE "MISTER PEEPERS," starring Wally Cox, Sundays, NBC-TV network.

No. 2 - Precision Operations in the Manufacture of ACME Chains



Battery of special case-carburizing and hardening furnaces impart an extremely hard wearing surface on Acme Chain pins and bushings to render longer and higher degree of service.



MODERN MANUFACTURING METHODS MAKE

ACME CHAINS

TOUGH and ENDURING

ACME Chains are designed and engineered to deliver positive power transmission and perform each specific job with maximum efficiency and economy. Sprocket ratio, chain impact, tension, drive speed and other factors are determined, not on the drawing board alone, but in the field where ACME engineers observe and test chains at work while new equipment is being designed. In that way, ACME Chains are made to deliver positive power transmission with economy and dependability under all loads at all times.

ACME Engineers are constantly at your service — just write or phone Holyoke 2-9458.

Write Dept. 9C for new illustrated 76 page catalog on use and application of roller chains and sprockets.

Acme Chain Corporation
HOLYOKE
MASSACHUSETTS

Personnel Service Bulletin

(Continued from page 850)

AGRICULTURAL ENGINEER for sales in specialized farm equipment field. Interested in representing manufacturer or distributor with equipment such as pumps, complete portable irrigation systems, power units, or related items with applications requiring sales engineer. One year sales in construction equipment. Two years sales engineer portable irrigation equipment. Middle Atlantic states. BS deg in agricultural engineering, 1950, N. C. State College. Two years enlisted service USNR in aircraft maintenance. Farm background. Married. No disability. Age 27. Available on reasonable notice. Salary $6000 or equivalent. W-443-83

AGRICULTURAL ENGINEER interested in design, development, research, writing or management in farm structures with distributor, consultant, or trade association. Any location. Married. Age 48. No disability. Experience 35 years in construction and building supply industry including work as senior construction engineer, construction engineer, general contractor, estimator-salesman, and general manager of lumber company. Available January 1. Salary open. W-423-84

AGRICULTURAL ENGINEER interested in design and development in power and machinery or processing field in industry. Location west of Mississippi River, in US possessions or foreign. Married. Age 29. No disability. BS deg in agricultural engineering, 1949, University of Nebraska. Design and development of tractor equipment 4 yr with two large manufacturers. Previous experience 8 mo as field surveyor for railroad. War enlisted and commissioned service in Air Force with training and experience in meteorology and navigation. Available on 30 to 60-day notice. Salary $8500 range. W-453-85

AGRICULTURAL ENGINEER interested in design, development, research, extension, teaching, or writing in farm structures or soil and water field, with industry or public service. Prefer location in Midwest or West. Willing to travel. Single. Age 36. No disability. BS deg in agriculture, 1943, Nortn Dakota Agricultural College. BS deg in civil engineering expected in January, University of Wisconsin. Instructor in farm structures, and structures engineer for Wisconsin branch experiment stations, 6 yr. War commissioned service in Infantry 3 yr. Available February 15. Salary $380 per mo. W-441-86

AGRICULTURAL ENGINEER for extension, promotion, sales or development work in farm buildings in industry, preferably in Midwest. BS deg in agricultural engineering, Iowa State College. Eight years experience with prefabricated buildings. Two years farm machinery sales. Farming experience. Married. Age 39. Available now. Salary open. W-451-87

NEW BULLETINS

(Continued from page 846)

An Electric Work Center for the Vo-Ag Shop, by R. N. Jones, E. F. Olver, D. R. McClay, and F. Anthony. Pennsylvania State College (State College) Progress Report No. 107 (August, 1953). Layout, bill of materials, and explanation of a cabinet unit for combining the demonstration board, electrical equipment and electrical work bench in one location in the vo-ag farm mechanics shop.

Penn State Mechanical Dairy Feeder, by E. F. Olver and R. N. Jones, Pennsylvania State College (State College) Progress Report No. 110 (November, 1953). Reports on experiments with hopper, conveyor, meter and tube systems to save labor in feeding grains. Continuing work is indicated on quick, easy adjustment and calibration of the feed meters.

Supplemental Electric Heat for Farm Buildings, by *Wm. H. Knight*. University of Idaho (Moscow) Farm Electrification Leaflet No. 23 (October, 1953). Brief text and illustrations on common types of electric heating units and their farm applications.

Bearings Can't Yell for Help!

but this

SUPER Seal

(EXCLUSIVE IN SEALMASTER BEARINGS)

can end two main causes of bearing failure

"... if you slip up by skipping lube periods, using the wrong lubricant, letting dirt into the bearing, you'll run into a string of bearing failures. Bearings have no way of yelling for help if they don't get the right attention. They'll just sit tight and take it ... until they fail."

POWERS Handbook on
BEARINGS AND LUBRICATION

Dirt or loss of lubricant can quickly grind the life right out of the finest bearings. SEALMASTER'S *unique double sealing principle protects you against both.* It's your best insurance against needlessly high maintenance costs and losses from machine downtime!

In SEALMASTER Bearings grooved steel inner seals assembled right into the outer race ring, on each side of the ball chamber, form the grease chamber.

Felt-lined steel flingers rotating in the grooves of the inner seals positively prevent dirt from entering the bearing. At the same time, the bottom flanges of these flingers, extending under and beyond the inner seal, create a vortex that breaks the grease flow and retains proper amount of lubricant.

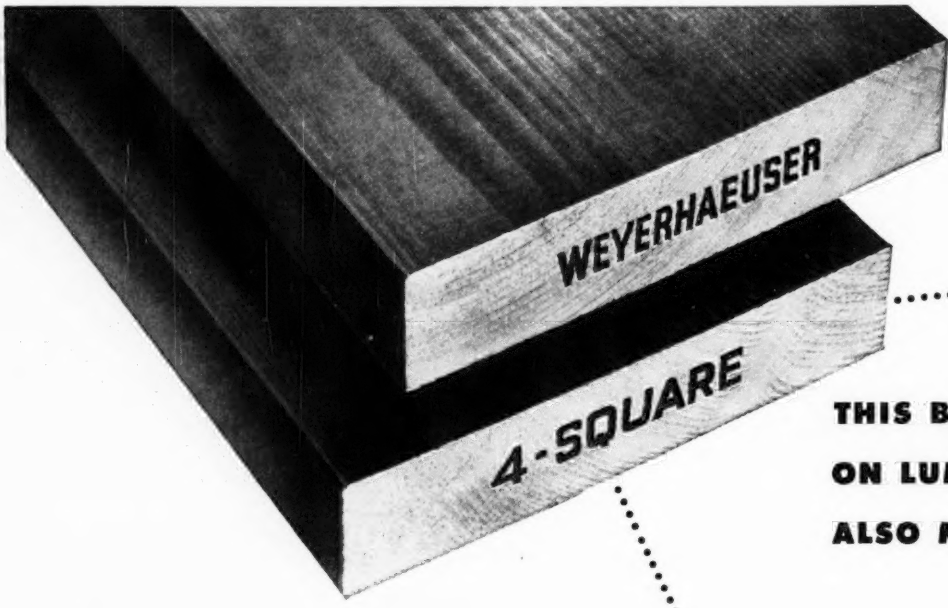
Even if your bearings do not have to take the abuse of "dirty jobs," you need the protection of the SEALMASTER seal. In *any* bearing application, it is your protection against needless maintenance costs ... it helps keep your machines running longer, better.

Why not write now for full information in our Bulletin No. 845.

Cartridge Unit | Flange-Cartridge Unit | Flange Unit | Take-Up Unit | Pillow-Block Unit

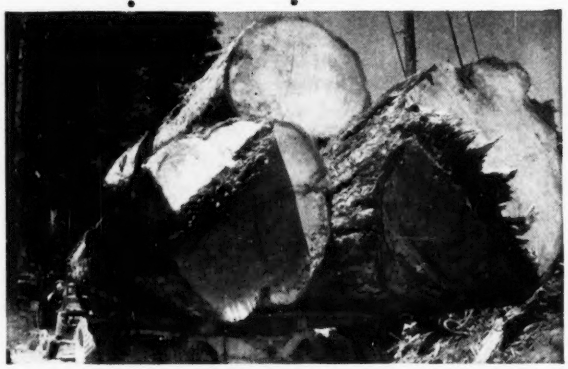
SEALMASTER BEARINGS • A Division of STEPHENS-ADAMSON MFG. COMPANY
67 Ridgeway Avenue, Aurora, Illinois

FACTORY REPRESENTATIVES AND DEALERS IN ALL PRINCIPAL CITIES

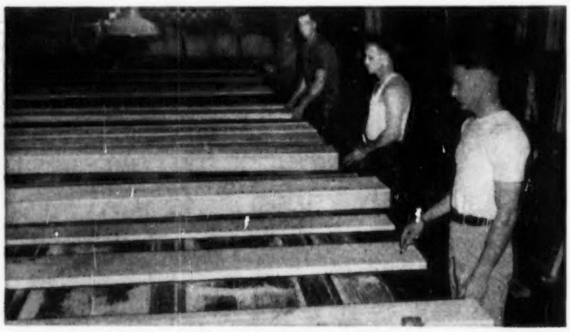


THIS BRAND NAME ON LUMBER ALSO MEANS...

1 **SCIENTIFIC HARVESTING**—Production of quality lumber products begins with progressive forest management and scientific harvesting. Weyerhaeuser practices continuous re-stocking of forest lands through natural re-seeding, or the transplanting of "superseedlings" such as those shown above.



2 **EFFICIENT LOGGING**—Modern logging is truly on the grand scale. Loads weighing up to 125 tons are carried in one trip on this mammoth truck unit, typical of modern Weyerhaeuser equipment. Logs reach Weyerhaeuser mills in prime condition to produce maximum lumber footage.

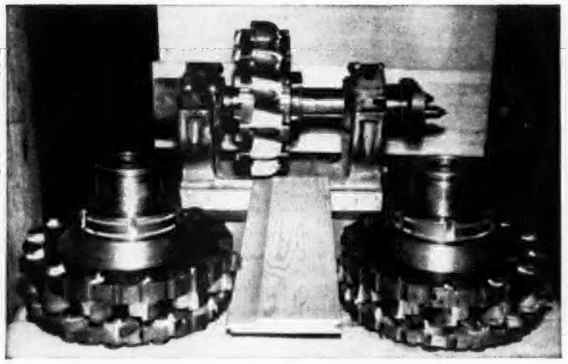


5 **CAREFUL GRADING AND HANDLING**—Extensive training courses are given to Weyerhaeuser grading and handling personnel. Skilled graders above are working on the "green chain". In handling, lumber is constantly safeguarded against damage to appearance or effectiveness.

Grade for grade and species for species, the brand name "Weyerhaeuser 4-Square" is the mark of reliable quality in the lumber field.

This brand name on lumber also means the coordination of modern timber harvesting, modern reforestation, and efficient, modern manufacturing methods. The result is high quality, properly seasoned lumber, which produces the utmost in sound, economical construction.

Quality Control in Every Process



3 **MODERNIZED MANUFACTURING**—At Weyerhaeuser mills, good logs become fine lumber in a highly developed and carefully controlled manufacturing process. For example, shaping of drop siding is done in the planing mill above. Three cutter heads cut tongue, groove and channel simultaneously.

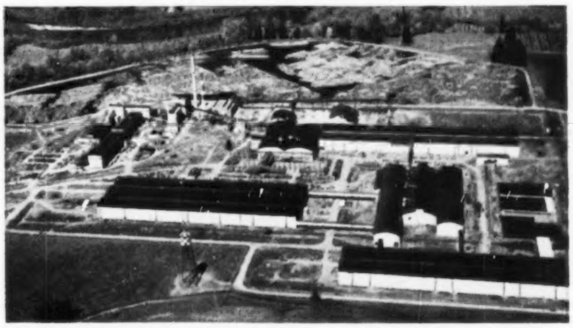
4 **CONTROLLED KILN-DRYING**—Today's quality-conscious market demands properly seasoned lumber. The Weyerhaeuser kiln-drying process is scientifically controlled at every stage. Lumber of proper and uniform dryness is assured by a carefully regulated process utilizing trained men and modern equipment.

Quality control as practiced by Weyerhaeuser means that builders can enjoy full confidence in this dependable brand name on the lumber they use.

For construction on the farm . . . homes, service buildings, or lumber-built equipment . . . Weyerhaeuser 4-Square Lumber offers durability, economy and lasting satisfaction.

WEYERHAEUSER SALES COMPANY

ST. PAUL 1, MINNESOTA



THE SPRINGFIELD, OREGON MILL—At mills located on the West Coast and Inland Empire, Weyerhaeuser 4-Square Lumber is produced in a range of products from Douglas Fir, Idaho White Pine, Ponderosa Pine, West Coast Hemlock, Western Red Cedar and related species.

Applicants for Membership

The following is a list of recent applicants for membership in the American Society of Agricultural Engineers. Members of the Society are urged to send information relative to applicants for consideration of the Council prior to election.

BARNES, BRUCE A. — General manager, R.C.S. Engineering Co., Glendora, Calif. (Mail) PO Box 347

BOWMAN, CHARLES C.—Instructor, agricultural engineering dept., Montana State College, Bozeman, Mont. (Mail) 909 West Dickerson

CHIDESTER, ROBERT L. — Project engineer, John Deere Planter Works. (Mail) 501 3rd Ave., East Moline, Ill.

CHRISTOFFERSON, DONALD F. — Layout draftsman, International Harvester Co., Stockton Works, Stockton, Calif. (Mail) 620 N. Harrison St.

COLEMAN, S. D.—Editor, The Business of Farming magazine, 300 W. Adams St., Chicago 6, Ill.

COMPTON, ERNEST F.—Agricultural representative and supervisor, Lennox Furnace Co., Columbus, Ohio. (Mail) 1035 Elizabeth Ave.

CYR, HENRY J.—Engineering trainee, New Holland Machine Div., The Sperry Corp., New Holland, Pa. (Mail) 320 Jackson St.

DAVIS, LEWIS K. — Student engineer, John Deere Waterloo Tractor Works. (Mail) Box 271, Hudson, Iowa

ELMORE, CLEON J.—Product engineer, John Deere Spreader Works. (Mail) 1309 E. Sixth St., Beardstown, Ill.

ESCHENWALD, ADOLFO H. — Associate professor of agriculture and mechanics arts, University of Puerto, Mayaguez, Puerto Rico. (Mail) College Sta. 454

EVANS, THOMAS — Chief engineer, Minneapolis-Moline Co., 1721 S. Seventh St., Louisville 8, Ky.

FORTIN, JEAN-MARIE—Professor of agricultural engineering, Ste-Anne-de-la-Pocatiere, Co. Kamouraska, Quebec, Canada

FRENCH, WALTER R.—Head, department of agricultural engineering, The Louden Machinery Co., Fairfield, Iowa

HACKLEY, DAVID S.—Mechanical engineer in charge of farm tire design, U.S. Rubber Co., 6600 E. Jefferson Ave., Detroit 32, Mich.

HASENBANK, KENNETH N. — Field engineer, J. I. Case Co., Burlington, Iowa. (Mail) 701 Harrison

HERUM, FLOYD L.—Research fellow in agricultural engineering, Iowa State College, Ames, Iowa. (Mail) 138 Pammel Court

HEWITT, WILLIAM A.—Vice-president and general manager, John Deere Plow Co., San Francisco, Calif. (Mail) PO Box 3573 Rincon Annex

HODGES, CARL E. — Agricultural engineer, Arkansas Agricultural Extension Service, PO Box 391, Little Rock, Ark.

ISEMANN, FRANK E.—District sales manager, Butler Manufacturing Co., 613 Cafritz Bldg., 1625 Eye St., N.W., Washington 6, D.C.

JORDAN, ELDRED A.—Instructor in agricultural engineering, Texas Technological College, Lubbock, Tex.

KAY, BENNETT M.—Farm electrification advisor, Northeast Oklahoma Electric Co-op, Inc., 229 S. Wilson St., Vinita, Okla.

MCCANN, NEIL F. — Agricultural adviser, United Kingdom Scientific Mission, 1800 K St., N.W., Washington 6, D.C.

MILLER, WILLIAM R.—Field test engineer, New Holland Machine Co. (Mail) RR 1, Sarver, Pa.

MOORE, WILLIAM C.—Sales representative, Bower Roller Bearing Co. (Mail) 7201 Summerdale Ave., Chicago 31, Ill.

PEACOCK, THOMAS W. — Assistant superintendent, Fleco Corp., PO Box 2317, Jacksonville, Fla.

PULLAR, JOHN L.—Assistant manager, Ames Irrigation Pty. Ltd., 60 Hunter St., Sydney, New South Wales, Australia

SCHUTMAAT, GEORGE W.—Owner, Hamilton Mfg. & Supply Co., PO Box 212, Holland, Mich.

SURTMAN, JULE R. — President, Carolina Ford Tractor Co., PO Box 1496, Charlotte, N. C.

WANKEL, WESLEY J.—Understudy to irrigation supervisor, P.F.R.A., Box 393, Maple Creek, Sask., Canada

WANSLEY, LAMAR T. — Assistant manager, Georgia Power Co., PO Box 1719, Atlanta 1, Ga.

WHITE, JAMES P., JR.—Experimental engineer, The Oliver Corp., South Bend, Ind. (Mail) RR 1, Box 317

WORSTELL, ROBERT V.—Work unit engineer (SCS), USDA, Box 1399, Lakeview, Ore.

TRANSFER OF MEMBERSHIP GRADE

BREVIK, THEODORE J.—Assistant professor of agricultural engineering, Michigan State College, East Lansing, Mich. (Associate Member to Member)

LARSON, RUSSELL E.—Agricultural engineer (bPISAE), USDA. (Mail) Agricultural Engineering Bldg., University of Missouri, Columbia, Mo. (Associate Member to Member)

It's WISCONSIN-Powered

On pruning alone, one man with a Wisconsin-powered Hi Tender outworks 6 men working with hand tools. This unit, built by Stemm Brothers Inc., Leavenworth, Wash., is also used for thinning and picking. Hi Tender *high-spot* features:

1. Rotates through 360°, for working 4 areas without repositioning.

2. Cage moves parallel to ground with in-and-out motion. New ease in getting *into* and *out* of tree.

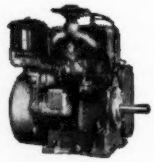
3. Unit supports 3 fruit boxes. Full boxes are lowered gently to ground, eliminating fruit damage.

Wisconsin Engine high-spot features:

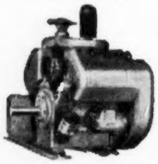
• Tapered roller bearings at both ends of crankshaft take up thrusts . . . no chance of bearing failure. • Fool-proof any-climate air-cooling. • Easily-serviced outside magneto with impulse coupling for fastest any-weather starts. • Heavy-duty construction, top to bottom. • Most popular farm-field power, 3 to 36 hp.

Write for information about all 4-cycle single-cylinder, 2-cylinder and V-type 4-cylinder models, 3 to 36 hp.

Single-cylinder models, 3 to 9 hp.



2-cylinder models, 7 to 14½ hp.



V-type 4-cylinder models, 15 to 36 hp.

MOST H.P. HOURS

WISCONSIN MOTOR CORPORATION

World's Largest Builders of Heavy-Duty Air-Cooled Engines

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Our **6** modern plants

in six separate locations

give you a stabilized, dependable

source for sleeve bearings

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The Cleveland Graphite Bronze Company

DIVISION OF CLEVITE CORPORATION

$700 saved . . .

more efficiency gained

with

STOW flexible shafting

courtesy
IOWA
MFG. CO.

That's the experience of the IOWA MFG. CO., manufacturers of this super-tandem crushing plant which employs a 1¼" STOW power drive shaft, operating at 800 RPM. A centrifugal clutch relieves sudden starting loads. Use of the flexible shaft as shown permits a swing of up to 90 degrees either side of the center line.

This is another fine example proving the efficiency, the practicability of STOW flexible shafting.

Why not consult with STOW engineers on your next power transmission problem. You'll find that Stow flexible shafting can really do a job for you!

Write today *for this free bulletin 525 and Torque Calculator, containing complete data on STOW flexible shafting. No obligation, of course.*

STOW MANUFACTURING CO.
39 SHEAR ST. BINGHAMTON, N.Y.

Agricultural Engineers' YEARBOOK

The first edition of an ASAE-sponsored yearbook, announced in the 1952-53 Annual Report of the Secretary, will be published and distributed to ASAE members early in 1954. It will be known as the AGRICULTURAL ENGINEERS' YEARBOOK, and each member will receive one copy without charge. It will be on sale to non-members at a price of $5.00 per copy.

The Yearbook will contain a wide variety of information, for which ASAE members have frequent need. The main features will include (1) a roster of ASAE officers, divisions, sections, committees, and individual members; (2) the constitution, by-laws and rules of the Society; (3) standards, recommendations, and engineering data officially adopted or endorsed by the Society, and (4) a directory of manufactured products that agricultural engineers will find helpful in their various fields of activity.

AMERICAN SOCIETY OF AGRICULTURAL ENGINEERS

ST. JOSEPH, MICHIGAN

the BADGE of him who BELONGS

DESPITE the *presumption* it sets up, mere membership in the American Society of Agricultural Engineers is no *proof* of a man's high rank in technical talent. It does prove that he has met certain minimum requirements and has earned the esteem of colleagues who sponsored his application for membership.

But the Society emblem is *evidence* that native talent, be it great or small, is enriched by fraternity with the personalities whose minds fuse to form the pattern of progress in the methods and mechanics of agriculture. The wearer of the emblem waits not for the debut of an idea, but is present at its birth and helps to guide its growth.

Be you novice or veteran, your membership in the organized profession adds something to your efficiency, your vision, your influence as an individual engineer. The Society symbol on your lapel is token that you "belong". Wear it.

STYLES AND PRICES OF ASAE EMBLEMS

With blue ground for Fellows, Members, and Associate Members — furnished either in pin with safety clasp or lapel button — $3.50 each.

With red ground for Affiliates — furnished only in pin with safety clasp — $3.50 each.

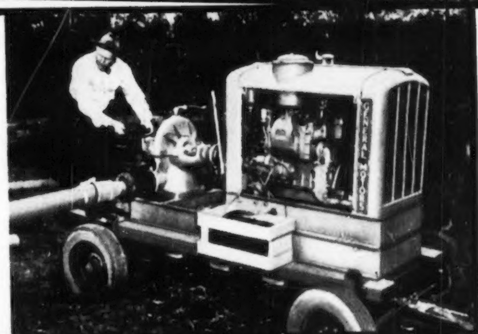
Send orders to ASAE, St. Joseph, Michigan.

SPEED FARM WORK–CUT COSTS 35 TO 60%

with General Motors Diesel Power

"More power, faster operation, less shifting in rough spots and on grades—and I save 60% in fuel costs," says Edward E. Staack, who repowered this tractor with a 3-cylinder GM Diesel. Farming 1,300 acres near Denver, Colo., Mr. Staack reports his tractor now makes four rounds in an 80-acre field of heavy clay in the time it used to make three. Fuel consumption averages 2.8 gallons per hour.

Extra power of a 4-cylinder GM Diesel on his 1200 g.p.m. pump enables Emmet Cabaniss of Maxeys, Ga., to irrigate 50% more pasture than he could with the gasoline engine it replaced. This trailer-mounted unit puts down an inch of water over three acres in an hour—protects crops against drouth—protects buildings against fire.



Fourteen GM Diesel-powered Speed Sprayers are used to spray citrus groves of Adams Packing Assn., Auburndale, Fla. Since switching from gasoline to Diesel power, maintenance costs have dropped 50% and fuel costs are down 35%. The 2-cylinder GM Diesel in each sprayer burns 2½ gallons of low-cost fuel per hour.

WHEREVER you have heavy farm work to do, you'll find you can get it done faster at lower cost with General Motors Diesel power. This Diesel is ruggedly built to withstand the pressures of fuel-saving 16 to 1 compression ratio. Delivering power at *every* piston downstroke, it's more compact, smoother-running and faster-accelerating under load. It starts at the push of a button, uses low-cost fuel, and gives you dependable, long-lived power with less servicing. On jobs like those above, a GM Diesel will quickly pay for itself in fuel and maintenance savings alone. For further information, write for free booklet, "For the Business Man on the Farm."

GM
GENERAL MOTORS
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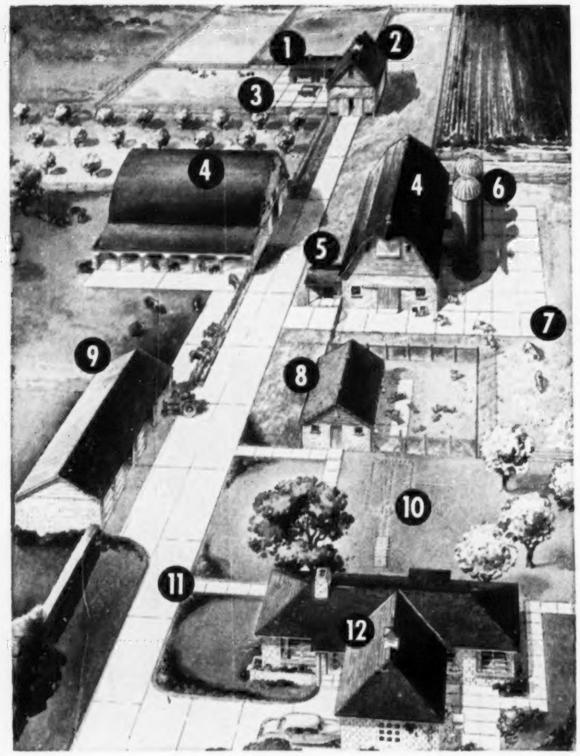
DETROIT DIESEL
ENGINE DIVISION
GENERAL MOTORS • DETROIT 28, MICHIGAN

Single Engines. . 16 to 275 H.P. • Multiple Units. . Up to 840 H.P.



Help Farmers Increase Profits with These Concrete Improvements

The above drawing shows 12 important farm improvements that agricultural engineers can design to help reduce work and increase production for their farm clients. Concrete improvements soon pay for themselves, yet continue to return dividends year after year.

Concrete is moderate in first cost, requires minimum maintenance and gives a lifetime of *low-annual-cost* service. Durable concrete resists damage from decay, termites, rats and storms. It reduces the ever present danger of disastrous farm fires. *Concrete can't burn.*

Yes, you perform a real service when you design concrete farm improvements.

FREE BOOKLETS on these improvements will be sent on request. Distributed in the U.S. and Canada only. Address department A12-1.

INDEX TO FARM IMPROVEMENTS ON DRAWING ABOVE

1. HOG HOUSES
2. CRIBS AND GRANARIES
3. FEEDING FLOORS
4. DAIRY BARNS
5. MILK HOUSES
6. SILOS
7. PAVED BARNYARDS
8. POULTRY HOUSES
9. MACHINE SHEDS
10. SEPTIC TANKS
11. WALKS AND DRIVES
12. CONCRETE MASONRY FARM HOMES

PORTLAND CEMENT ASSOCIATION
33 W. Grand Ave., Chicago 10, Ill.
A national organization to improve and extend the uses of portland cement and concrete . . . through scientific research and engineering field work

ASAE STANDARDS . . . RECOMMENDATIONS . . . CODES . . . DATA

The American Society of Agricultural Engineers has in recent years developed and approved several items of reference material, indicated by the above heading, widely used by agricultural engineers, most of which is not available from other sources. This material is made available as printed separates. These separates are printed on tough, heavy paper stock and are punched for filing in 3-ring, loose-leaf binders. The Society also has in stock a quantity of Accopress binders made of a durable grade of black pressboard, specially provided for filing the separates for ready reference, and with the above heading imprinted in yellow letters for easy identification. The separates and Accopress binder can be purchased from the Society headquarters office at prices (postpaid) indicated below for each item. (Any ASAE member may purchase one copy of any separate—not the binder—listed below at one-half the published price.) Quotations on quantity orders of any separate will be furnished on request.

(N.B. All separates listed below are to be included in the contents of the new 1954 *Agricultural Engineers' Yearbook* to be issued annually hereafter by the Society.)

ASAE STANDARD: APPLICATION OF HYDRAULIC REMOTE CONTROL TO FARM TRACTORS AND TRAILING-TYPE FARM IMPLEMENTS. Covers common mounting and clearance dimensions. Eight-page separate. Price per copy 40 cents.

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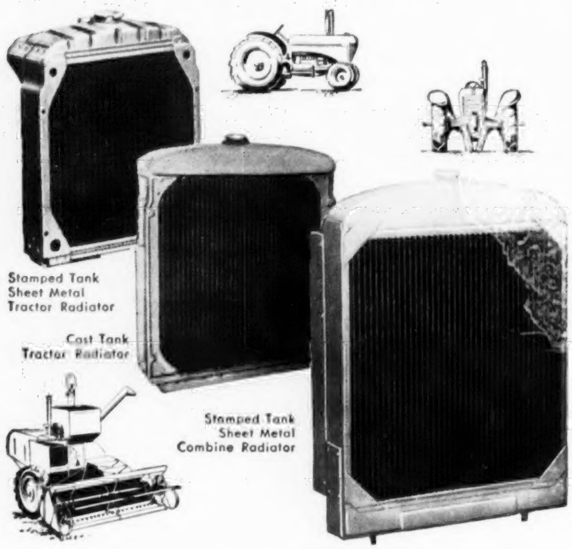

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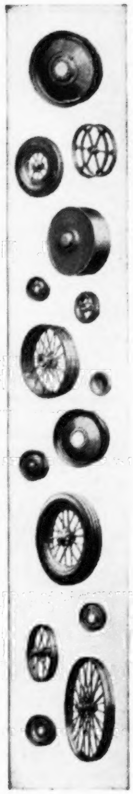

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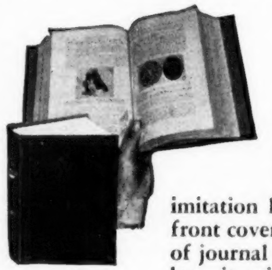

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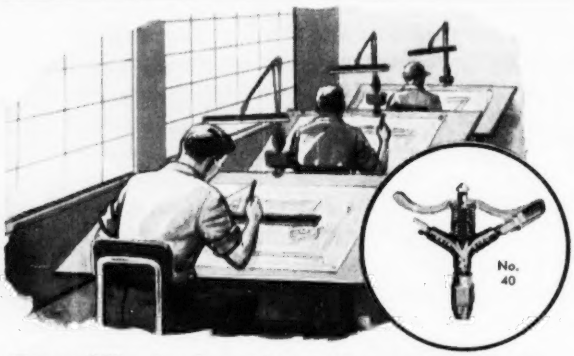

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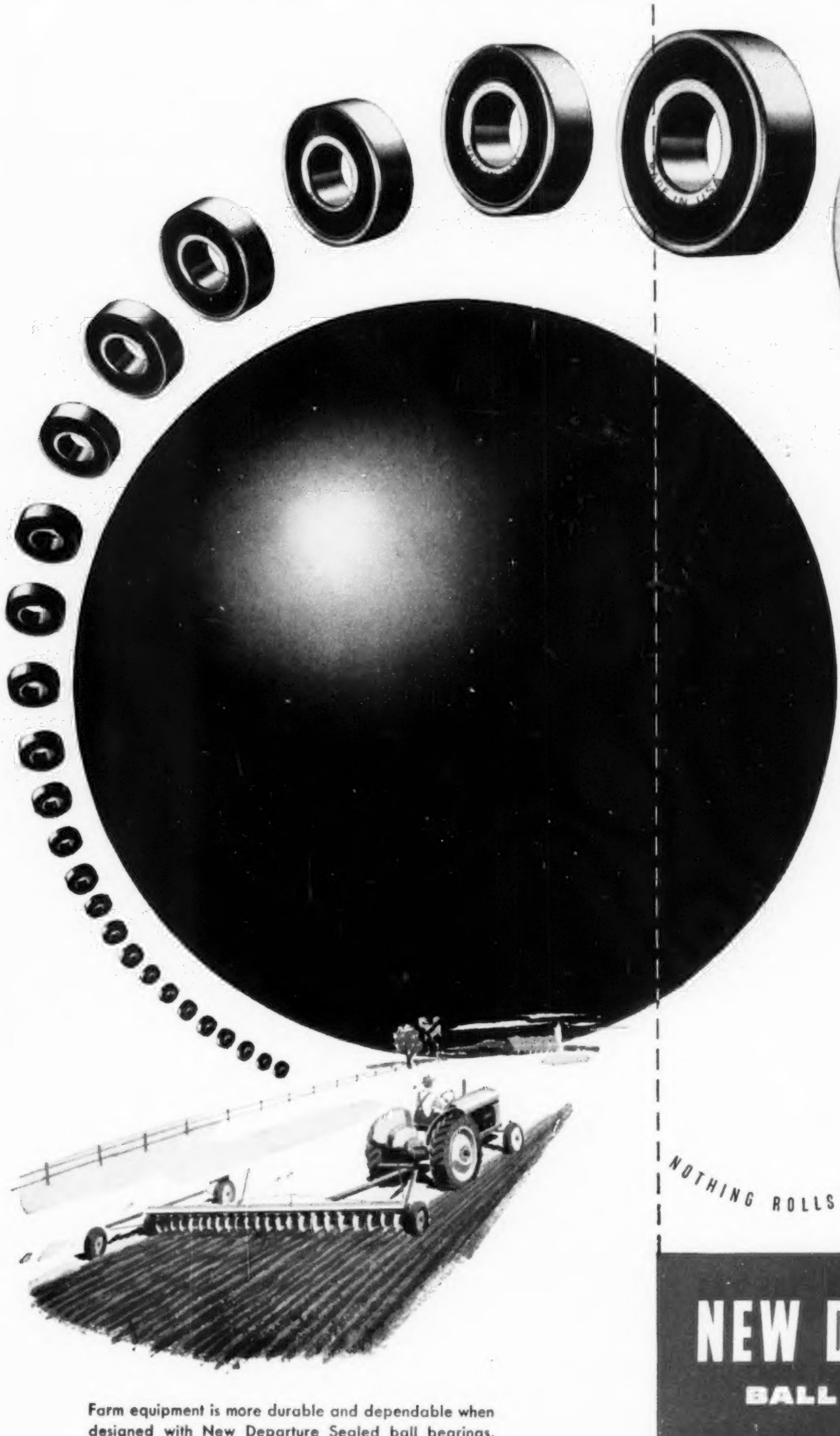

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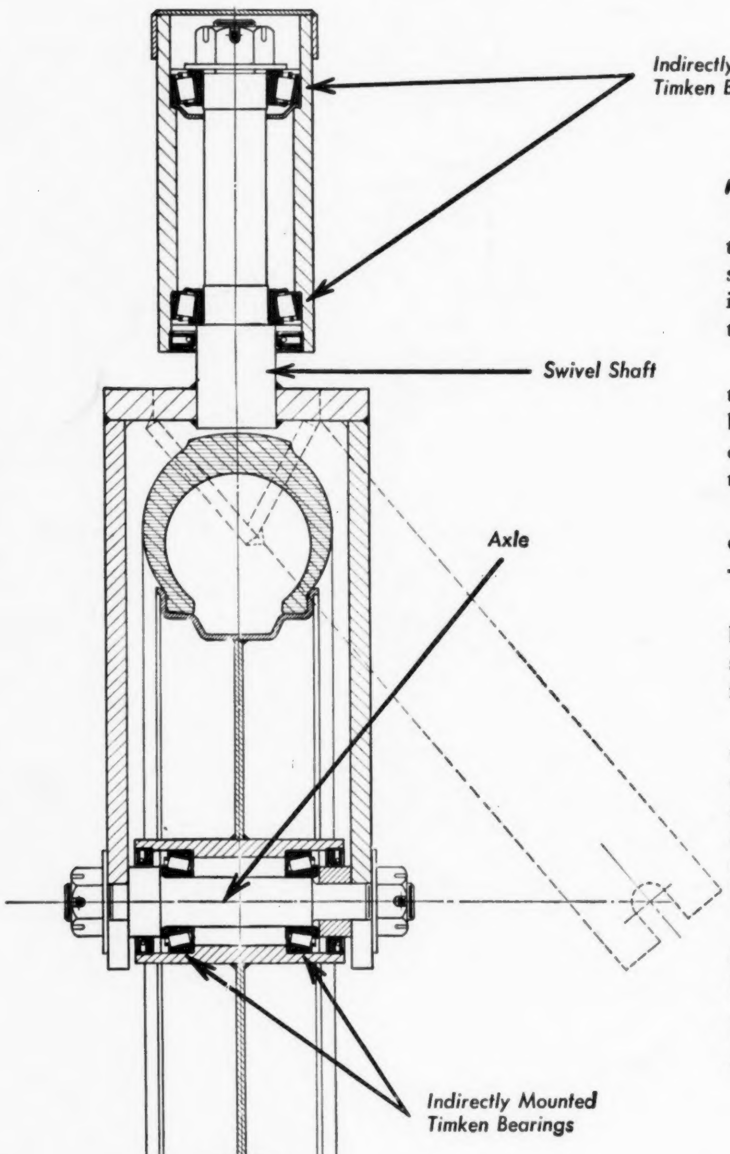

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